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Engineering and Mining Journal

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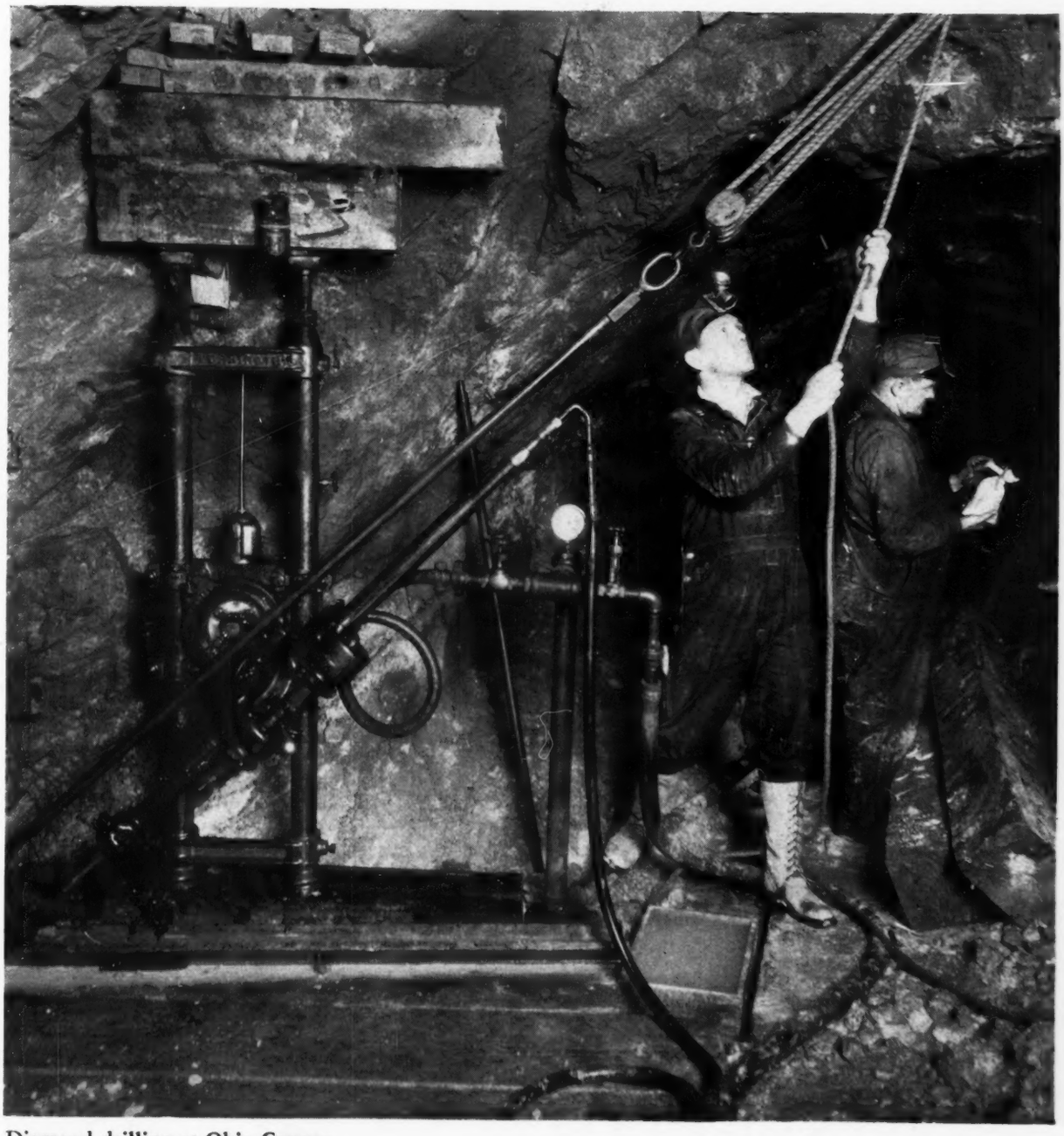

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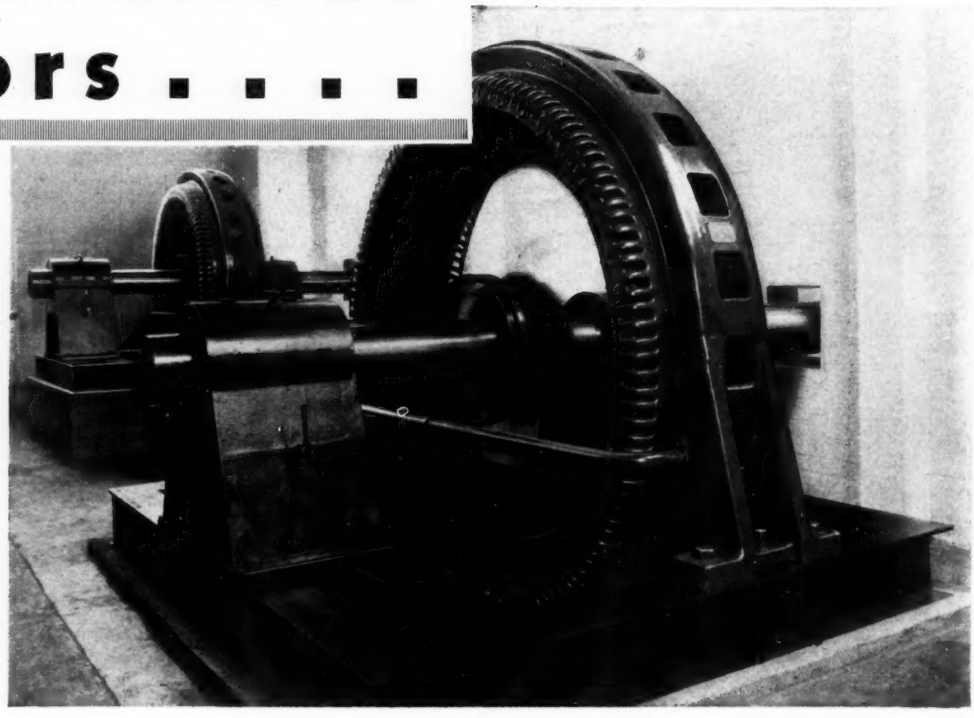

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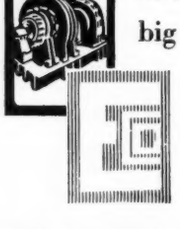

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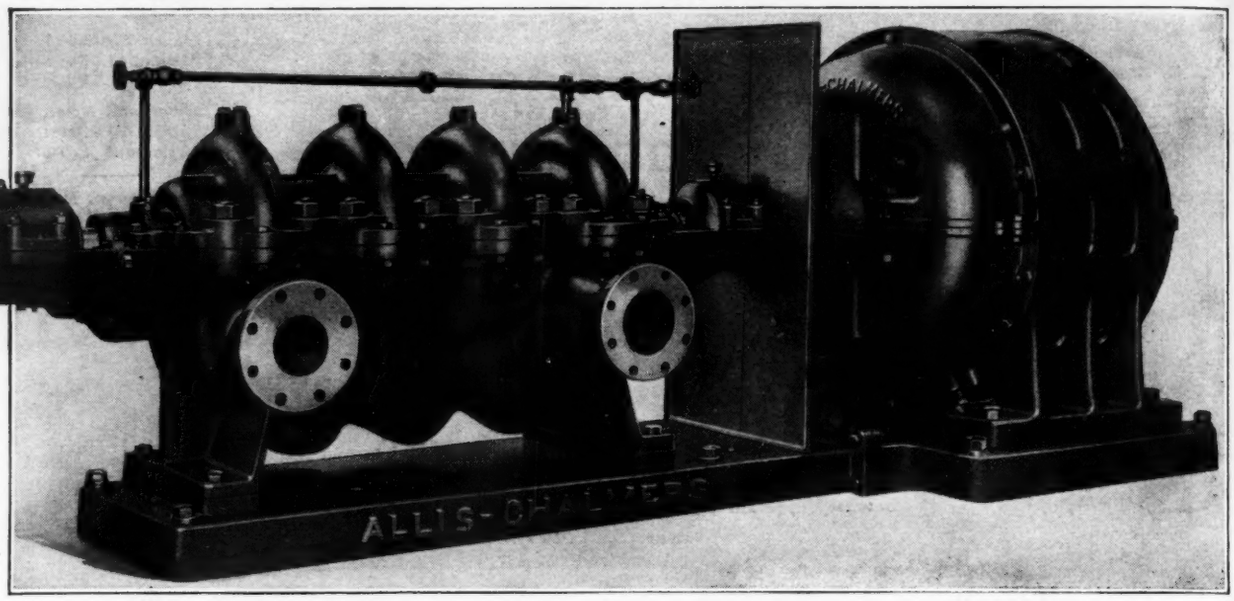

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Engineering and Mining Journal

June 8, 1931 A. W. ALLEN, *Editor* Vol. 131—No. 11

Taking the Bumps Out of the Business Cycle

SINCE the days when Joseph first interpreted Pharaoh's dream as an omen of prosperity followed by depression, the so-called business cycle has been one of the pet playthings of the industrial economist. It is, in fact, his stock in trade; it gives to his science, by virtue of its regular recurrence, a semblance of order. Although prone in the past to observe this phenomenon, no one has taken action about it, one way or another. Those who are most fortunate in flush times have managed, if they possessed the gift of foresight, to do well enough when the period of depression arrives. But those who are never more than on the borderland of well-being, and who live in the manner commonly described as "hand-to-mouth," have been left to shift for themselves, with occasional aid from governmental sources when the suffering has become acute.

Bankers are not unsympathetic creatures. They have noted the plight of a stratum of their fellow men and have offered advice. This, unfortunately, has been somewhat akin to that offered by Marie Antoinette, who, when told that her people were starving for want of bread, suggested that they eat cake. The great masses, dependent on a daily wage for their sustenance, have been told to ameliorate their distress in times of bad trade by saving in times of good. But, as Mr. George Bernard Shaw has pointed out in his most recent book, how can anyone save when his wages are barely more than sufficient comfortably to house, feed, and clothe himself and his dependents?

The solution of the bankers being interesting, but hardly practicable, one must look to others for an answer. A combination of the ideals of the economist, the labor leader, and the engineer, made public on Nov. 21, seems to hold out promise of accomplishing something definite in securing uninterrupted employment for workers. Governor Brewster of Maine, speaking before a conference of governors at New Orleans, outlined a plan whereby a $3,000,000,000 state and federal reserve construction fund will be created, for use in times of industrial depression. Construction work, particularly in the field of highway and bridge building, possesses the advantage that it is not directly productive, in the sense that it will not release additional commodities on a market already flooded by a surplus. At the same time it creates additional buying power by giving employment to men who otherwise would be unemployed. Much of this work can safely be deferred to periods of depressions, and that is what the sponsors of the reserve fund propose should be done. The existence of poverty and disease in a nation prosperous and rich in natural resources constitutes an indictment of the intelligence and capacity of government and industry and emphasizes the failure of science and morality to safeguard social well-being.

Although the feasibility of such a measure has been considered for several years, it was first offered in its present form by Mr. William T. Foster and Mr. Waddill Catchings, of the Pollak Foundation for Economic Research. It has received the approval of organized labor through the medium of the American Federation of Labor. But the serious consideration now being given to it by government officials and private business men may be attributed to the fact that it was presented to the conference of governors at the direct suggestion and with the hearty approval of President-Elect Hoover.—*Reprinted from the Dec. 22, 1928, issue of "Engineering and Mining Journal."*

Testing of Zinkiferous Cyanide Solutions

A REPORT of metallurgical tests contains the information and conclusion that "the free cyanide, as determined by silver nitrate titration, checks with the total cyanide titration. This indicates that the excess of caustic soda reacts to change the double sodium-zinc cyanide and produces a free cyanide titration equal to the total cyanide." On due consideration, however, the question may be raised as to whether or not any appreciable amount of free cyanide is formed by the addition of caustic soda to a zinkiferous cyanide solution used in the operation of leaching and filtration plants. Is it not probable that the issue has been confused by a failure to distinguish total cyanide from free cyanide, possibly because of the method of testing adopted? A change suggesting the release of free cyanide may be inferred, but sufficient evidence seems to be available to show that the free alkali when present gives an erroneous estimate of free cyanide when titration is made with silver nitrate solution, and if potassium iodide be used as an indicator. The reaction involved can be stated convincingly in the form of an equation.

The suggestion has been made over a considerable period of years that research and investigation should decide the most practicable and accurate method of testing a typical working solution for free cyanide, the actual percentage of which is of paramount importance. The necessity for the neutralization of free alkali present, before the titration with silver nitrate, should be acknowledged, or the reliability of an alternative method must be explained in the form of an equation acceptable to the cyanide chemist and supported, not discredited, by solubility tests.

California Moves to Stabilize Mineral Production

STABILIZATION of the oil industry of California is the objective of a bill under consideration by the Legislature of the State, providing for the creation of a commission of six persons, comprising the state superintendent of oil and gas and five members to be elected by the oil companies. It aims to legalize a pro-rating system, already in force. A second bill is designed to prevent waste of gas by excessive drilling.

Limitation of output may be expected to insure more orderly production methods and the stabilization of marketing. Such efforts at scientific management connote control, which in turn implies the fixing of prices. The alternative has been well illustrated in the recent history of the oil industry—increasing output in an effort to reduce unit production costs, accumulation of unwieldy surpluses, demoralized prices, local supension of operations, industrial and social disorganization.

The California experiment will be watched with interest, in the hope that the results will prove helpful and suggestive to other mineral industries affected by the prevailing marketing disorganization and lack of leadership direction. Ample moral justification exists in support of the legal attempt to be made in California to stabilize production and price, to remedy present chaotic conditions prevailing in one major commodity market in that state.

Engineers as Administrators and Managers

FOLLOWING closely on the publication in a recent issue of a suggestive article by Mr. Francis G. Hill, on "Training the Mining Engineer to Direct and Control," comes announcement that Cornell University is proposing a course in administrative engineering. Entrance requirements will remain the same as formerly, according to Dean Dexter S. Kimball, who explains that credit hours required for graduation number 147, of which 91 are for engineering and allied subjects now included in the regular four-year course in mechanical engineering. The remaining 56 hours are given mainly to history, economics, finance, and similar subjects, almost all of which are now offered in other colleges of the university. The course is not intended as a preparation for commercial or business pursuits, but to fit graduates for administrative positions in engineering and industrial life.

The Cornell proposal recalls Mr. Hill's forceful analysis of the problem in the field of mining engineering, particularly in regard to his insistence that the quality most needed in the controlling and directing force is breadth of knowledge and qualification. "This force," he maintains, "is, in essence, management, as distinct from such work as mining, surveying, sampling or ore dressing. One who is to take such responsibility must have special training; he must be trained to deal with fundamentals, to see an industry in relation to other industries and in relation to its own parts; in short, to see industry as a whole. To maintain that such training can best be acquired by a slow mastery of details in each of the channels traversed is wrong," Mr. Hill contends. "The 'old school' believed thus—believed that knowledge should be gained by long experience rather than by experiment or by studying the experiences of others; but such slow meandering tends to create a disposition to imitate rather than to investigate and initiate." The objective inferred in these criticisms can best be attained by the inclusion, in current curricula at educational institutions, of distinct courses in scientific management.

Opportunities for Production Economies

INDUSTRY today is making a determined effort to reduce operating costs to a level that conforms with current economic conditions. The dismissal of labor or wage reduction—customary remedies during past industrial depressions—is being avoided as much as possible because of the danger involved of increasing the economic disequilibrium, to the detriment of all industries and wage earners. Means to achieve the desired objectives, therefore, must be found at the plant proper. The forward-thinking executive will take the opportunity to make a careful plant survey in regard to machinery, production methods, operating schedules, and waste.

Although conditions have been improved materially at the average plant in recent years, the ideal of perfection—in respect to scientific plant control—the scrapping of obsolete machinery, improved plant layout, and the avoidance of all waste—has not been reached. Power, maintenance, and lubrication are subjects still being treated negligently. One must bear in mind that waste is not limited to the scrap pile. More than the value of supplies and equipment so scrapped may be lost in other ways; as, for instance, in leakage of steam and water, and escape of heat because of improper insulation; waste of lubricants, and dust losses, owing to the lack of central oiling and filtering plants, and inadequate dust-recovering facilities; and, finally, the careless selection and application of electric-driven machinery, with the attendant evils of power waste and increased over-all costs.

Installation of electric motors of a capacity consistent with the power required to drive a fan, pump, hoist, compressor, and other mine and mill machinery is of the utmost importance. One still finds at many plants a 25-horsepower motor driving a 5-horsepower fan, or a 50-horsepower motor at the machine shop when one of 30-hoursepower would meet amply the power requirements. The contention raised that no suitable motor was available at the time of installation cannot be accepted as an excuse. It indicates a lack of foresight, as the cost of a suitable motor is usually far less than the cost of the power otherwise wasted annually. Such apparent waste of power, often unrealized, is sometimes the main cause of high production costs, especially at plants operated by companies that purchase power. A frequent survey of electrical and mechanical plant machinery by the maintenance engineer, and the willingness of those in executive power to put his recommendations into practice, will invariably result in lower power costs and increased plant efficiency.

Cost Standards and the Personal Element

INSISTENT is the demand for cost statements, particularly in regard to mining and metallurgical operations. But the inquisitive should be warned that the following of a lead and the duplication of plant and process are not alone necessary to duplicate results. On the other hand, many a noteworthy process has been denied recognition because of the ease with which it could be maltreated by those who disdain frugality and see no connection between simplicity and efficiency.

Costs mean nothing unless the personal inclinations of those in control of operations are taken into account. A high cost may serve to discredit a highly useful and practicable technical process. A low cost may indicate a fortunate combination of experience and zeal in preliminary planning as well as in subsequent operation. Even the most efficient plans can go awry when no incentive exists to translate them into economical practice; so the inexperienced imitator may fail to duplicate the results obtained elsewhere after many years of trial and discard. Good machinery and logical flow sheets are essential to success, but equally necessary is a directing mind with an understanding and a co-operative spirit.

Mining Reports by Free Lance Writers

NEW YORK, according to a prominent Broadway hostess, has become effete and dull. Her departure is reported. Reasons for the choice of Reno, Nevada: "The one spot in America not infested with Puritans . . . where the smart people are." Disregarding the entanglements in and disentanglements from games of chance, for both of which Reno is now internationally famous, the engineer can turn for entertainment to a remarkable report emanating from the Nevadan capital and designed to foster interest in mining enterprise. This particular record of promotion progress commences with unusual naïveté: "Owing to the untimely death of the Secretary of the Company, who served faithfully for ten years, the financial report is not included." Dividend disbursements have commenced, nevertheless; and stockholders may look for uninterrupted rewards. The first dividend consists of share per share in another company. The second dividend, promised, of share per share in yet another company. "Both these companies are actively developing their properties," one learns, "and are very meritorious." History does not relate what compensation goes to the corporations so deprived of their stock.

The description of progress given in this report makes quaint reading: "There has been a lot accomplished during the year just passed, although it was a very trying one with lots of grief attached to our efforts. We have reached the stage in our development where we can look forward to continued returns for our faith. Your officers have worked hard and conscientiously against very hard and trying conditions; we have had the moral support of some very fine stockholders—stockholders who have stuck with us through thick and thin, rumors and innuendoes, and to those we wish to express our full appreciation for their confidence in our project and in our efforts and management. . . . The officers of your Company have worked hard, and have suffered a great deal of grief in making the stock attractive, and have endeavored at all times to develop your Company into one of the outstanding mining issues of the West. And we are doing just that. We are gradually accomplishing our purpose, and we are feeling most optimistic as to our future. We are playing for big stakes, and the outlook is quite promising to produce a winner. All of our property will bear investigation. They have been investigated by skeptical stockholders a great many times and we invite thorough investigation."

The geological reports are fearful and wonderful pieces of testimony and information. Extracts read as follows: "The veins occur in fissures in the slates. Usually accompanied by an intrusion of Diorite, from 12 to 20 feet wide. The veins themselves are probably of Dioritic origin, Metamorphosed by heat pressure and circulating mineral bearing waters to Amhibolite Schist. This is particularly true of the ——— veins. This vein is opened up for a length of 750 feet. Averaging from 8 to 20 feet in width, at a depth of 500 feet below the surface. A Diorite dyke follows the foot wall. A Talcose Amphiobolite-Chloritic Schist, streaked with gold bearing quartz seams, compose the vein filling. The hanging wall is an Agrillsceous slate of remarkable cleavage and silvery gray luster near the vein; both luster and cleavage declining as the vein is left behind."

Mining methods to be employed are summarized thus: "The width of the veins and the length of the shoots encountered, along the strike of the veins, is conducive to most economical ore extraction; in that it can be mined by the shrinkage system, reducing the use of timber to a minimum, avoiding square setting in stopes, or other expensive methods of holding up the walls. . . . The progress of the ore in the mine, from the time it is broken in the vein, will be to fall by gravity into the mine chutes, thence by gravity into the cars, then to the Grizzly, to sift out the fines, thence by gravity to the rock breaker, thence to the Mill ore bins, then through the feeders to the stamps, thence over plates and concentrators. All by gravity. The plates to amalgamate the free gold, the concentrators to separate the sulphides from the gangue. The tails or gangue flows to discard, while the sulphides flow to a ——— Mill to be ground to a 300 mesh, thence to a leaching tank to be cyanided. Every step of this process will be be gravity until the worthless pulp enters the railing pond." Gravity of gravities, saith the writer, all is gravity.

The gem of the collection, however, is a statement from the report of an alleged geologist, which reads as follows: "I have given the ——— Mine a recommendation, based upon economics and the conjugated vein system, with the relationship, that Igneus intrusions are of the male gender, and that the mineralizers were there at the proper time. Also the fault system is entirely absent."

Public confidence in the mining industry is not enhanced by such publicity, circulated to existing and prospective investors in mining property. Unfortunate, moreover, is the fact that a report may be signed and issued by almost anyone who has the nerve to add "Mining Engineer" or "Geologist" after his name. The problem involved is as worthy of consideration as is the one concerned with the actions, ethical or unethical, of recognized members of the mining profession.

Precise Shaft Surveying—

A Factor in Achieving Efficient Ore Hoisting

. . . . Accurate alignment in sinking operations and positioning of sets insures low maintenance costs and maximum output

Arnold B. Black

RECOGNIZING that one of the most important factors in the economical operation of a mining property is the efficient transport of broken ore from underground to mill bins, Broken Hill South, Ltd., operating a silver, lead, and zinc property at Broken Hill, New South Wales, Australia, in planning and sinking its new hoisting shaft at the South mine, took particular care to insure accuracy in the attendant survey work, not only in establishing connections with existing workings but also in the vertical alignment of shaft timbers. Several features of the technique employed are believed to be original, and these, together with a detailed account of the survey control exercised over the entire project, are presented here.

The South mine, one of the "Big Three" (North Broken Hill, Broken Hill South, and Zinc Corporation), at present the only active properties in the district, occupies mineral leases Nos. 7 and 8 on the Broken Hill lode. The length of lode in these leases is 2,500 ft. Ore reserves are 4¼ million tons, and ore hoisted during the year ended June, 1930, was 337,000 long tons, with an average assay of 14.6 per cent lead, 5.3 oz. of silver per ton, and 11.2 per cent zinc. The total ore won from the mine to date is 7½ million long tons.

The orebody, down to the 1,070-ft. level, is naturally divided in two sections, the northern and southern ends. In the former, ore extraction may be said to be completed, whereas in the latter section the orebody is developed ready for concentrated attack. Fig. 1 shows the state of the 825-ft. level after connection of the new No. 7 shaft; the 625-, 725-, 970-, and 1,070-ft. levels are in a similar condition. The 1,170-, 1,270-, and 1,370-ft. levels are still being worked in the northern ends; the southern ends are partly developed.

At present the ore is hoisted in No. 1 shaft, centrally situated to the northern workings, in cages. Through this shaft, put into operation twenty years ago, have been hoisted about 5 million long tons of ore. In addition it has served as a man and supply shaft. The company, having proved the existence of large reserves in the southern end of the mine, decided to sink No. 7 shaft. This is a six-compartment frame-set shaft, 9 ft. 6 in. by 20 ft. 10 in., inside of timbers (see Fig. 2), the sets being spaced 5 ft. center to center. Four of the six compartments will accommodate two cages, for men and supplies, and two 5-ton skips; the other two compartments will be used for electric cables, pipes, and ladders. Provision will be made at each shaft station for a magazine, tool depot, weighbridge, ore tippler and ore pass to the loading station, the necessary ore and supply truck lines, water cistern, and a concrete house for electrical switch gear and transformer. The first loading station is under the 1,070-ft. level, and the second under the 1,370-ft. level.

Surface arrangements will include a steel headframe of the vertical-sided A type, concrete hoist house and crusher station, electric hoists with Ward Leonard control, and "Lilly" overwind controllers. The cage hoist will be operated under manual control. Operation of the skip hoist will be entirely automatic. The "double-purpose" shaft is new to the South mine, and, with one small exception, is new to the field. The concrete hoist house is also a new departure, and, excepting several small shaft hoists at the South mine that are operated by alternating current, electrical hoisting is an innovation at Broken Hill.

A general idea of the development done in the south end of the mine is presented in Fig. 1. All of this work was controlled through the northern end surveys. Although all the connections were satisfactory, the survey was not considered accurate enough, and a resurvey was undertaken in the southern portion of the mine. Early in 1924 the survey department started the following campaign:

A surface traverse, connected to the eastern boundary of mineral lease No. 7, was run between Nos. 3 and 4 shafts. Two independent surveys were made and the mean values accepted.

Survey stations, set in concrete, were placed in front of each shaft, and on separate days a single wire—22 gage, brass—was dropped to the bottom level in each shaft. The wire was weighted with a 20-lb. four-winged bob, suspended in oil. In later work, phosphor-bronze wire was found more satisfactory. At each underground level and at each shaft these wires were "picked up" from survey stations set in wooden plugs in holes bored in the back of the crosscuts.

As daily work permitted, traverses were run between the shafts, using the

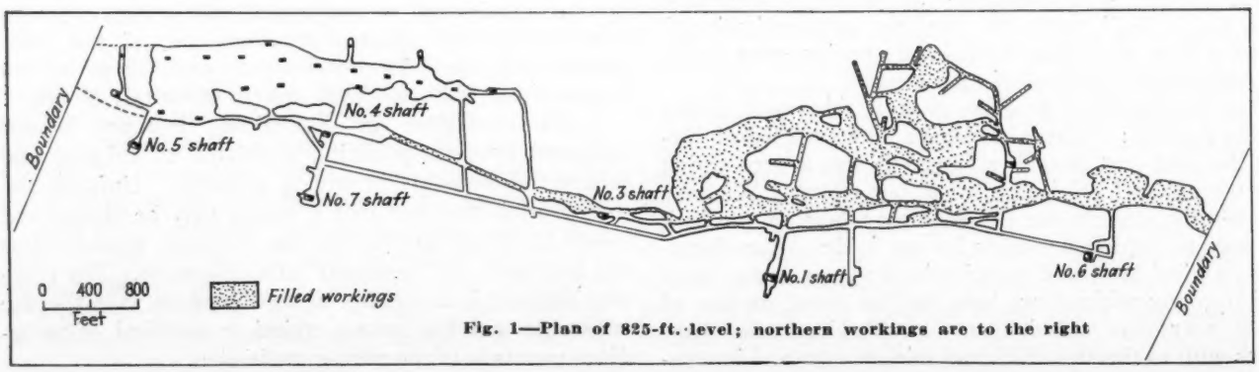


Fig. 1—Plan of 825-ft. level; northern workings are to the right

existing azimuth on each level. These traverses were calculated and adjusted in the usual way for a two-shaft survey. Taking into account the surface and underground traverses, the closing error, starting in every case at No. 4 shaft and finishing at No. 3 shaft, varied from 1 in 9,000 (on one level where short lines were common) to nil, this latter actually occurring on the 1,170-ft. level.

The method of working was that usually employed on the South mine. A Watts No. 6 standard theodolite and 150-ft. stainless steel tapes were used throughout the survey. The angles were read from zero and doubled. Distances were read by two operators, and checked again, if necessary. The straight line distance between the wires was 604.70 ft., the surface traverse was 952.09 ft., and, on the 1,170-ft. level, for example, the distance was 750.455 ft. The long and arduous work entailed in resurveying the surface and twelve underground levels has been fully justified by the excellent connections made between the new shaft and existing workings, and also between the pilot winzes mentioned herein.

Fig. 3—Logitudinal section showing pilot winzes

In sinking, the shaft was commenced at the surface, full size, about 12 ft. by 23 ft. outside the timber, and at the same time crosscuts were put out from each level to the site of the shaft. Pilot rises and winzes were started from these crosscuts. After the full-sized shaft met the rise from the 250-ft. level, stripping was carried on. The arrangement of these winzes is shown in Fig. 3. One side of the winze was designed to make one end of the shaft, so that subsequent stripping operations would be simplified. To accomplish this, reasonable accuracy of survey was necessary. That no stripping has been found necessary on the shaft ends provided by the winzes and rises may be noted here with satisfaction.

The position of the shaft having been determined, the coordinates of the inside corners and center were calculated, as were also the bearings and distances of those points from a near-by survey station. Center lines were laid out for erection of the headframe and winch used in sinking operations, and the four corners of the shaft marked for the preliminary excavation. When sufficient sinking had been done, long 10x10-in. stringers were laid across the excavation and securely fixed vertically above the position of the shaft corners. Four brass survey marks were then put in the under side of these stringers, one at the correct position of each corner of the shaft. Measurements of the sides and diagonals of this rectangle checked exactly with the shaft dimensions.

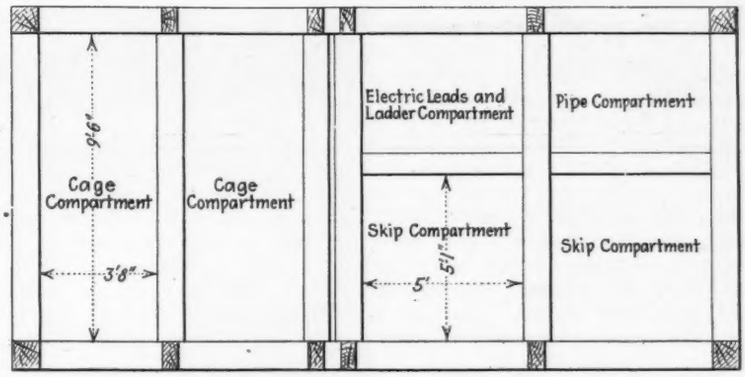


Fig. 2—Cross-section of No. 7 shaft

From the 10x10-in. stringers, the shaft frame sets were hung and blocked to position under the brass marks. On the first set the timberman nailed the usual wooden chocks and hung their plumb bobs from the included angle. When about 60 ft. of timber—that is, thirteen complete sets—was in position, the whole was supported with a concrete backing. This definitely fixed the shaft collar against movement, besides waterproofing it and doing away with the need for timber bearers. The inside corners were then picked up from the surface survey, and the actual coordinates and shaft bearing calculated. These values varied but little from those previously determined and laid out.

The winzes were sunk 12 ft. by 5 ft., one 12-ft. side being the end of the shaft. Two indicator points were given on this side, 11 ft. 6 in. apart, so that the miners had to give at least 3 in. clearance from the strings hung from these points. Fig 4 shows the position of the winzes and the corner or indicator points in relation to the shaft. The coordinates of the indicator points were calculated, using the previously found corner coordinate values and shaft bearing. The bearing and distance to one of the indicator points from a convenient survey station were then worked out, and this line was laid off on the job. A hole was bored in the back, plugged, and the usual brass survey mark placed in the correct position. The second indicator point was placed, using the shaft bearing and a distance of 11.50 ft.

For the rises the indicator points were placed 20 ft. apart and 1 ft. 3 in. from the side of the rise. It was found convenient to plumb down from the back of the rise, onto a string stretched between these two indicator points. The placing of these indicators insured that the miners had definitely fixed marks to keep the winze or rise in its correct position. Inspections were made frequently by the surveyor.

When concreting of the shaft collar was completed, a plumbing station staging was fixed on the second ring of timber below the surface, leaving the greater part of the bucket and counterweight compartments open. On this stage the following gear was assembled:

Four small pulley wheels mounted on mild steel bars (see Fig. 5). These were fixed across the shaft corners at the plumbing station and remained in place for about 400 ft. of sinking.

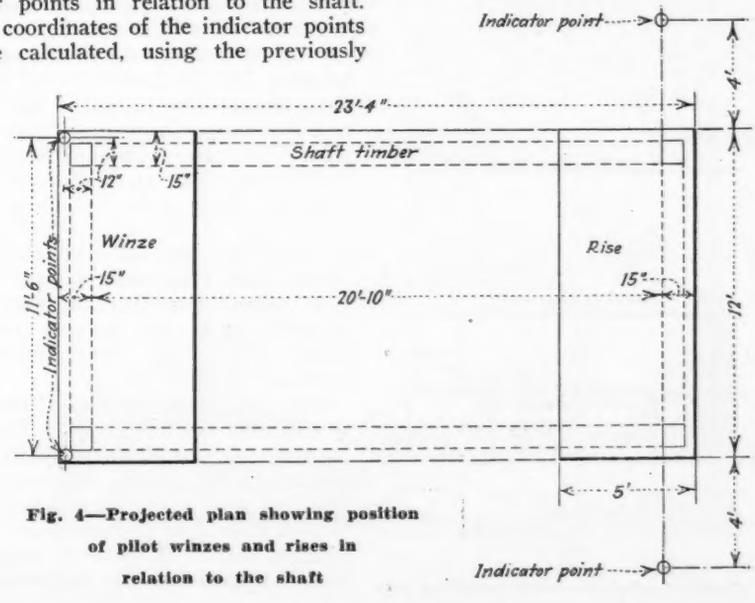
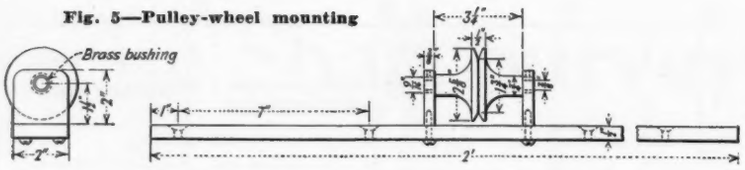


Fig. 4—Projected plan showing position of pilot winzes and rises in relation to the shaft

Fig. 5—Pulley-wheel mounting



Four reels of shaft plumbing wire, 20 gage phosphor bronze. This wire was wound on hand winches (see Fig. 6), nailed to the staging, one looking toward each shaft corner. Each wire had a snap hook at the end for easy attachment of the plumb bobs.

Four egg-shaped bobs. These were designed to readily pass by the timbers, and were used only when lowering and raising the wires.

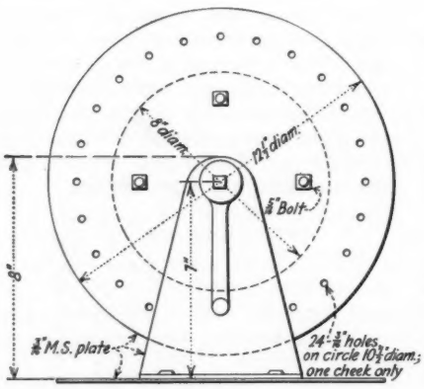
Four 20-lb. cylindrical, winged leaden bobs.

Four galvanized-iron buckets for suspending the winged bobs in water (see Fig. 7). The handle was designed to fit across the shaft corners on the bottom ring of timber and to allow the bucket to hang free of the suspended winged bob.

Four corner plates of ⅛-in. mild steel. These plates (see Fig. 8), slotted to receive the timbermen's plumb line, were placed in correct position by the surveyor.

A 400-ft. reel of two-wire cable mounted like a windlass. The outer end of the cable was connected to a bell push, and the inner end to a discarded electric lamp base.

An electric buzzer was connected to the 110-volt lighting circuit, a lamp holder being attached for connection to the reel of cable. A code of signals, based on those listed in the Mines Inspection Act of New South Wales, was used. To a depth of 100 ft., vocal signals sufficed.



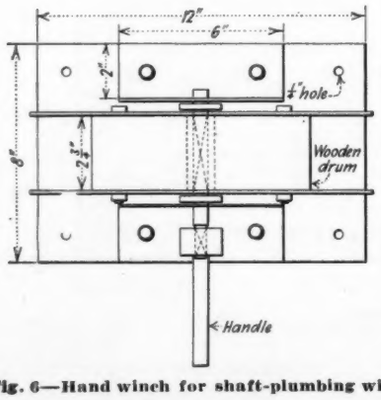


Fig. 6—Hand winch for shaft-plumbing wire

Before shaft sinking was resumed after concreting the collar, the plumbing points for the timbermen were fixed in the following manner:

The four pulley mountings were placed across the shaft corners, an 8-oz. surveyor's plumb bob was hung over each wheel, and the base bar of the mounting shifted until the string was 1 in. from the inside of the wall and end plates of the shaft timber.

Measurements of the sides and diagonals of the rectangle formed were checked against calculated distances, and adjustments made. At this and subsequent plumbing stations those in charge of operations found it was not possible to set the strings exactly 1 in. at each corner, owing to small errors in cutting the timber. After checking up, the pulley mountings were screwed down. On the set immediately below, the four corner plates were fixed, the slots in the plates surrounding the bob strings, so that the strings were centrally situated in the back end of the slots. Four 4-in. wire nails were used in each plate. These were driven halfway and bent over, to make removal easy in what is generally an awkward position for the operator. This completed the first placing of the corner plates, and, from then on, the survey department fixed all plumbing points used by the shaft timbermen. The strings used by the latter were white cotton schnapper lines, about $\frac{3}{16}$ in. in diameter, which fitted snugly in the end of the slot in the corner plates.

The timbermen placed the sets 1 in. from the center of the lines. This amount of 1 in. can be visualized while blocking the set, and the final adjustment made, using the plain 1-in. mark on a 2-ft. rule. The fixing of the corner plates was repeated at approximately 50 ft. intervals; that is, below and above each plat, the position varying with the circumstances. In every instance, two or more sets beneath each plat were backed with concrete, similarly to the shaft collar. Generally, the bottom set of this section was selected, and the corner plates were fixed before any more sets were placed.

This concreted section takes the place of the usual timber bearers. The next position of the corner plates was usually in the next to the bottom set, when the shaft timbering was suspended to permit the next plat being cut. This position was 25 ft. to 35 ft. above the level. Experience has indicated that 400 ft. of shaft is a convenient limit to plumb from any plumbing station. Longer distances were investigated, but difficulties cropped up owing to the wires being so close to the timber. One inch was the most suitable distance for the timbermen, and other matters were regulated accordingly.

The routine of transferring corner plates required a party of three men, one man at the plumbing station and two

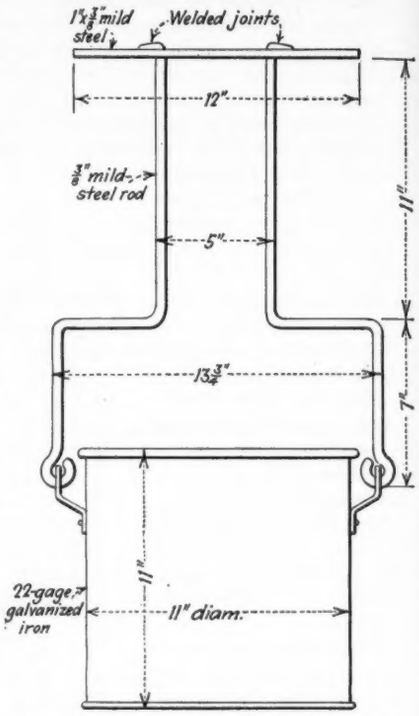
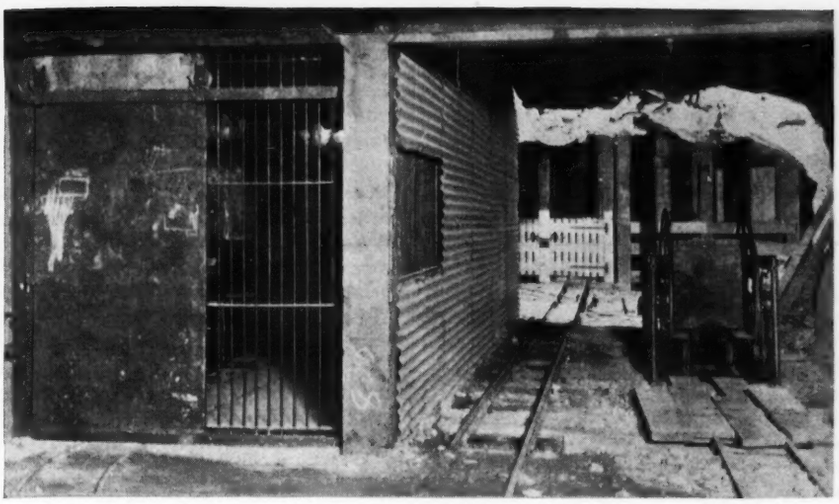


Fig. 7—Bucket used in shaft plumbing

men in the shaft. The buckets, winged bobs, hammer and nails were collected and taken down in the sinking bucket to the bottom set; meanwhile the top man saw that his gear was in order and let down the buzzer cable, stopping it on receiving a signal on the pipe line. He then attached the buzzer and awaited signals; under no circumstances was he allowed to lower a wire until signaled to do so. One of the other two men had by this time commenced to clear the shaft corners, taking out the corner plates and timbermen's lines, and also removing any stagings and timber dogs. The third man, keeping the other aware of his position, had meanwhile been fixing the necessary staging, placing the buckets under the bottom set and filling them with water. When all was ready, the top man was signaled. In the required corner he passed the wire over the pulley, clipped on the egg-shaped bob, and commenced lowering. If a fourth man were available, he was

Fig. 8—Corner plate



Shaft station at 825-ft. level of No. 7 shaft. Tool depot and ore tippler in foreground. Shaft in background.

stationed here to pull the wire out into the shaft so that the bob dropped clear of the timber. When the bob reached the bottom staging, the "stop" signal was given, and the large four-winged bob clipped on in place of the smaller one; with further signaling, the height of the bob was adjusted until the top of it was just beneath the water. "Stop," "all clear," and the next corner signals were then given. The signal code employed was as follows:

1 bell, Stop.
2 bells, Lower.
3 bells, Raise.
5 bells, All clear.
1 bell, 1 bell, North corner.
1 bell, 2 bells, East corner.
1 bell, 3 bells, South corner.
1 bell, 4 bells, West corner.

When all four bobs were down and steadied, a glance was sufficient to determine if any wire was much out of position. If all wires appeared correct, the diagonals and sides of the rectangle were measured and checked against the top measurements. Any discrepancy indicated that one or more wires were fouling the timber—a small splinter was sufficient to cause a discrepancy. After satisfactory checking, measurements were taken to the timbers at each wire. Actually, no error exceeding $\frac{1}{4}$ in. was found, and generally the error was less than $\frac{1}{8}$ in. The corner plates were then nailed on, as already described, the small bobs replaced on the wire; and hoisting signals given. The gear was then collected and returned to the plumbing station. Two to three hours were required for this work, which was usually done on Saturday mornings. The five-day week is worked in this district, and on Saturdays the surveyor has a clear field. During the timbering operations, placing of the shaft sets was checked regularly by the foreman and frequently by the surveyor.

So far as I am aware, this method of shaft alignment has many novel features, at least in this field.

The plumbing station was changed at 400-ft. intervals. The corner plates were put in as usual on a concrete-lined set below the 425-ft. level and the 825-ft. level, respectively. During the following week, the pulley mountings were brought down; and, with an 8-oz. plumb bob over them, were adjusted until the strings hung in the slots of the corner plates. Side and diagonal measurements were checked against correct distances, any necessary adjustments being made before putting in the holding-down screws.

In check plumbing from the surface to the 1,070-ft. level, four wires, one in each corner of the shaft and 6 in. from the timbers, were let down from the surface. Two measurements from each wire to the sides of the shaft were taken at each level. The greatest variation from 6 in. was $\frac{1}{4}$ in., and 60 per cent of the measurements varied $\frac{1}{8}$ in. or less.

To expedite the completion of the shaft, a second section was commenced below the 1,370-ft. level. This entailed a new survey to place the shaft plumb lines exactly on this level. Through pilot winzes from the 1,170- to the 1,270- and 1,370-ft. levels, and the adjacent No. 4 shaft, the survey was transferred to the 1,370-ft. level. The plumbing wires at the 1,170-ft. level were picked up and coordinated. These positions were established on the 1,370-ft. level, as already described in discussing pilot winzes. Sinking was then started, and the top timbers were concreted in. Sinking, early in 1931, had advanced nearly to the 1,470-ft. level, and a loading station had been cut 30 ft. below the 1,370-ft. level. The closures between the three traverses necessary were exact, and no difficulty is expected in joining up the two sections of timber perfectly.

In carrying elevations down the shaft, a bench mark, with its value reduced to sea level, was placed at the collar set on the end plate of the bucket compartment, 1 ft. from the runner. Similar marks, in the form of a "T," are driven in the same position at each plat sill and at any other points required. When the timber was about to be placed below a plat, a bench mark was put in the lowest set above, the plat timber being stood later. The reduced level of the plat sill was calculated, and a note given to the foreman, informing him of the distance from the bench mark to the top of the sill timber. The level of this set was afterward checked by the surveyor.

At present (February, 1931) the cage and skip guides are completed from the surface to the first loading station, between the 1,070- and 1,170-ft. levels, and the skip loading gear is complete. The hoist house and crushing station are well advanced, and erection of the headframe will be commenced soon.

Those in charge of the work anticipate that everything will be ready for operation on June 30, by which time many working parties will have been transferred to stopes in the southern part of the mine. The advantage of the large open stopes then available and the new hoisting shaft will be apparent in increased tonnage and reduced costs.

Acknowledgment is here made to the Australian Institute of Mining and Metallurgy for permission to include in this article much of the information that appeared in the paper "Survey Work in Connection With the Sinking of No. 7 Shaft, Broken Hill South, Ltd., Broken Hill, N. S. W.," published in the Proceedings No. 79, 1930. Thanks are also due to the management of the company for permission to write this article.

Bisbee Orebodies Reviewed

Carl Trischka

FROM what can be seen of them, the basic Pre-Cambrian rocks of the Warren district in Arizona were originally sedimentaries, sandstones mostly, greatly folded and altered to a sericite schist, which was later intruded by a granite porphyry. Mineralization must have accompanied this intrusion. Evidence of it is found in the form of sulphides of copper, lead, and zinc, and gold-quartz veins. In both schist and granite the original mineralization may have been strong, but all that remains after long erosion are roots of mineralization. These are not important economically, though efforts have been made to exploit them. Occasionally, someone comes to Bisbee with a specimen of gold-quartz rock; and, if the time is ripe, a sort of "boom" results to the west of Bisbee on Juniper flats, which eventually dies down. This has been going on for fifty years, or ever since the first arrastre was built, the remains of which are still to be seen.

As the Pre-Cambrian rocks became submerged, in Cambrian times, they were covered by a basal layer of cross-bedded pebbly sandstones, which was followed by a final thickness of about 500 ft. of sandstone. This is now known as the Bolsa quartzite. It has remained almost unexplored, despite the fact that sulphide of iron and copper have been found in several places, though nothing of commercial importance. Discovery of ore in the quartzite would not be surprising.

As submergence continued, a series of thin-bedded limestones with sandy layers near the top were laid down for a thickness of 700 to 800 ft. This is the Abrigo limestone, characterized by wavy-banded structure, epidotization, and castellated-surface weathering. Fossils are rare, occurring mostly as fragmental trilobites, although atripa are found in the upper part. Chert beds also are rare. Copper mineralization of economic importance is found in the upper 150 ft. of this formation. Its type, size, and importance will be discussed when referring to the Don Luis area.

Rocks of Ordovician and Silurian age may be absent entirely, but a quartzite 8 to 30 ft. thick is sometimes found, known locally as the Ordovician-Silurian quartzite. This, a valuable marker, is readily recognizable because of its coarse-grained particles, milky white in color and vitreous in fracture. Silver ores and one of the only two outcrops of ore discovered early in the district were found in this formation.

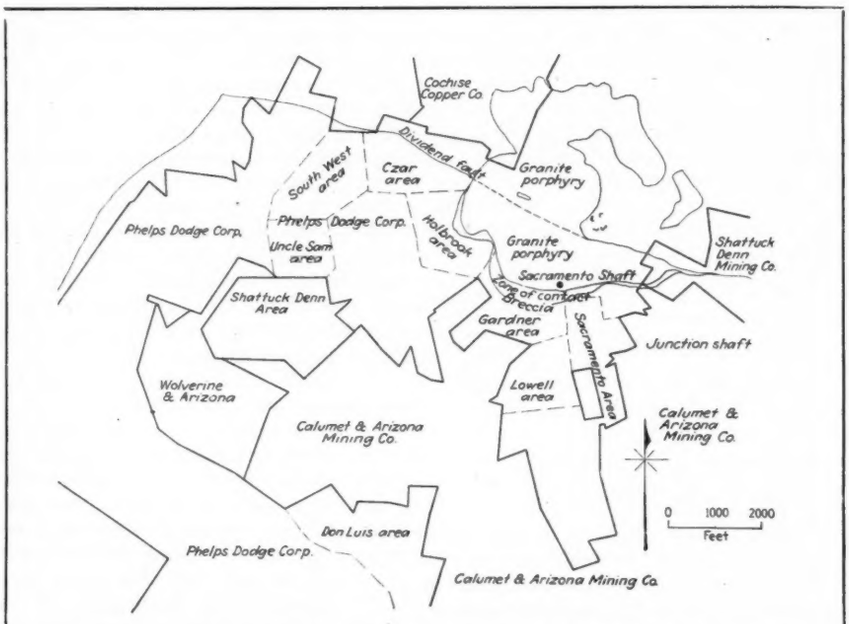
On top of this quartzite is found a Devonian limestone, black and shaly, which in its upper layers grades into a fine-grained bluish limestone. It averages 325 ft. thick and is very fossiliferous, especially at its center, where atripa and spirifer abound. The lower layers contain large and distinct crinoid stems. This formation was once considered the most important with respect to ore deposition or ore occurrence, but later work in the other formations has deprived it of this distinction.

Between this formation and the next one above, sometimes extending into one formation and sometimes into the others, is found a 20- to 30-ft. series of fine-grained blue to gray limestones, which weather to a pinkish shade. They are known locally as the "pink beds," and, although not always readily distinguishable underground, constitute a valuable marker on the surface. Close examination shows that they originally contained finely disseminated syngenetic pyrite, which weathers on exposure to iron oxide, which in turn gives the pinkish tinge to the rocks.

On the Devonian limestones was laid down 3,000 ft., more or less, of Carboniferous rocks. Of this, about 800 ft. is known as the Lower Carboniferous, or Escabrosa limestone, and the upper as the Naco limestone. As there are no remains of, or probably never were any, Jurassic or Triassic rocks in this part of Arizona, the top of the Naco limestone is an old and irregular erosion surface.

The Carboniferous limestones are very fossiliferous. A series of layers about 20 ft. thick, especially prolific in Productus fossils, are used as a dividing line between the Upper and Lower Carboniferous. Although this may not be a strictly correct division, it is a valuable means of locating oneself geologically on the surface and underground.

Unconformably on the Carboniferous is a conglomerate of Cretaceous age known as the Glance. In thickness this is variable, being at least 1,00 ft. in one place, and in others it may never have existed. It is interesting geologically, although lacking economic importance, and is composed mostly of unsorted, angular, subangular, or somewhat rounded boulders. A boulder as large as an ordinary room is frequently found next to boulders no larger than a melon. Fragments of all of the rock described thus far compose it. In some areas the schist predominates; but, in drilling down into it, the contact with the underlying Carboniferous limestone is seen to approach as the content of limestone boulders increases. Also resting on the Carboniferous in many instances are remains of the detrital material resulting from the erosion of the Carbonifer-



Map showing location of areas in the Warren mining district, in Arizona.

ous hills laid down before Cretaceous times.

The sandstones, limy sandstones, and limestones of Cretaceous age of great thickness that rest on the Glance conglomerate are also of geologic interest but of no importance economically. They may be dismissed with the statement that they contain very fossiliferous layers of limestone and belong to the Comanche series of the Cretaceous. No formations occur later than those given, recent detritals excepted. Quartz veins and andesite dikes of Post-Cretaceous age are found, but the gold content of the former is so spotty and low that, although attempts have been made to exploit them, they have never become economically important.

THE mode of ore mineralization is of prime importance, and the following history of the genesis of the ores is the result of observation and deduction on the evidence found. It is a dramatic story, in spite of the present static state of the geologic phenomena. Though complex, conditions are presented as clearly as they can be read at present. Later evidence may modify the present opinion, but will not change it greatly.

Imagine conditions at the end of Carboniferous times. The land is being eroded, and a large deep-seated laccolith is gradually forcing itself under the formations, doming them. This continues until the formations are unable longer to resist the pressure; whereupon they yield, the rocks crack, and the steam and other gases of the magma are released. An explosive volcanic crater is formed, before any of the igneous rock and minerals that are being differentiated from the magma have become molten or formed, and the crater is filled with fragments of the crater wall rocks and ejectamenta that have fallen back into it. Mount Pelée, on Martinique, was observed to act similarly. Igneous rock, in the form of a rhyolite, wells out of the crater; and, as it comes, it drags with it the fragments mentioned, creating a contact-breccia zone between the limestone and the rhyolite. This flow continues for a while, but after it stops the rhyolite in the crater (still hot) gradually changes to a granite porphyry. Fragments of all of the rocks from Pre-Cambrian schist to upper Mississippian are found closely associated with one another in this zone, and all mixed. The explosion has also created numerous breaks in the rocks that radiate from the crater, and some concentric to it, in a pattern similar to that resulting when a bullet penetrates a piece of glass.

Faulting has also taken place especially along the major axis, now called the Dividend Fault. At present, the displacement on this fault is about 3,000 ft., though in the beginning it was probably less. Movement over a zone several hundred feet wide is doubtless still gradually going on. This fault was probably originally an overthrust fault because, if the ground were restored to its position prior to the tilting after Cretaceous times, it would be found to be a reverse fault in places.

Block-faulting took place over an area 2 miles wide and 3 miles long, bounded by the Dividend Fault on the north, the Black Gap Fault on the east, the Quarry Canyon Fault on the west, and the White Tailed Deer system on the south. This was intensified and complicated because, as the porphyry left the crater from below the area just mentioned, the limestone blocks were pushed about and dropped. This helps to explain the district's complicated faulting, which is so difficult to trace. The folding, faulting, breaking, settling, and other movements that followed the major disturbance must have been extensive and intense.

Porphyry dikes and sills shot out into and along the openings and breaks in the formation; and, during this churning about of the fault blocks, even though it may not have been violent nor intense in the later stages, the ground was broken up and prepared for the mineralizing solutions that followed and deposited the ore. Certainly there was much pulverized, cracked, twisted, and loosely aggregated rock, as well as large and small channels and paths for the solutions. Once the mineralizing solutions came, they must have followed each other during several periods. They must have died down or even disappeared between periods, but they came over a long time and differed from each other in their mineral constituents. They extended no doubt into Post-Cretaceous times, as indicated by the Quartz vein.

The porphyry was cooling, and shrinkage cracks were being produced in it while the solutions were mineralizing the limestones. Some of these cracks were filled with sulphides and silica. The shrinking helped the settling or slumping action of the main area and produced new or additional channels for the mineralizing solutions. All solutions to be described contained copper sulphides in varying amounts. They are given as types and not in order of their coming, because the order is not known and the effects of one period certainly overlapped those of another.

One sulphide-bearing solution contained pyrite principally, with some chalcopyrite and bornite that traveled only a short distance from the granite porphyry, or was disseminated more particularly in the granite porphyry itself, where, to a great extent, secondary enrichment of the pyrite created the present workable deposits of porphyry ore. The original copper content did not exceed one-half of 1 per cent.

Silica predominated, in another mineral-bearing solution, and this created the pronounced and well-known silica outcrops, as well as silicifying the porphyry and large areas of limestone at or near the limestone-porphyry contact and in the contact-breccia zone. The copper in this solution was small in amount.

Still another mineral-bearing solution was no doubt low in sulphur and high in iron, and this accounts for the magnetite and hematite deposits, which are rather more common than generally known or found in other copper-mining camps. Also, it accounts for the formation of the primary chalcocite, and what may be the primary native copper that has been found. At any rate it accounts for the higher forms of copper sulphides.

Another period had varying amounts of the sulphides of lead and zinc with silver, and in general traveled a considerable distance from the main stock of granite porphyry. It also contained pyrite and chalcopyrite. Some of the manganese oxides found with the oxidized copper ores may be the result of the alteration of alabandite. The strong and important solution which contained considerable sulphur, iron, and copper is responsible for the large, extensive and rich orebodies of the district. Without it Bisbee would amount to but little. Chloritization and the formation of tremolite and small amounts of garnet no doubt are due to some solutions.

How much time elapsed between these periods, their exact sequence, the extent to which they overlapped each other, the pressure and temperature conditions, as well as a great many other features are not understood. The faulting, folding, and other manifestations of dynamic movements due to the tilting of the limestones before and after Cretaceous times still further complicated the relationship of ore and its source. Individual periods, if they could be tied down definitely as to their paths and minerals, may well demonstrate the zonal distribution theory, but the effects of these have been destroyed by later mineralization and by intense oxidation, which is unusually irregular and deep in the district. A rough zonal distribution of minerals can be recognized if certain areas are considered by themselves.

ORE occurs in isolated areas with nothing leading out of the orebody in any direction to show how it got there. Practically no garnet or epidote zone, which is usually so common to contact metamorphism, occurs. Garnetization and epidotization are seen in only a few places, and tremolite is found but seldom. Replacement of the limestone stops against a thin gouge or a fault gouge; and, although chlorite is common, especially in the contact-breccia zone, the main effect at the contact of the granite porphyry and the limestones is marbleization, and during oxidation

a kaolinization of the limestone results.

Sulphides that are not even secondarily enriched are found 100 to 200 ft. above completely oxidized orebodies, because the block in which they are contained was more or less impervious to oxidation influences, whereas the blocks below were not. Ore is found along breaks, at intersections of breaks, and along the contact of porphyry and limestone. It is found at times in the folds of the limestone where the bedding has separated. In this condition it resembles a shoot in a vein deposit, or a long cigar-shaped deposit or lens.

The ore has arranged itself in the limestone around the granite porphyry of Sacramento Hill, in the granite porphyry, along breaks leading from it, and on the contact of limestone and pohphyry dikes, as well as in the contact breccia zone around the granite porphyry dikes, as well as in the contact of varying size have been replaced by sulphides and silica.

When it came up, the porphyry separated the strata, "leafing" them as a thumb would the pages of a book, and penetrated to variable distances into these openings, thus formed, making a vertical section through this contact look like one through a petticoat insulator of a high-tension line. Ore occurs here also where the limestones project into the porphyry mass. The projections of limestone surrounded or partly surrounded by porphyry are favorable localities for ore. Ore is often found where the porphyry has formed domes or embayments, and there are several phases of porphyry, some of which are more often associated with the ore than others. Some of these phases are quite basic.

The north side of the Dividend Fault has been eroded rapidly because it is the upthrow side. No commercial ore is found here, although the dissemination of sulphides is probably as strong as on the south side, especially in and near the granite porphyry. The tenor of this sulphide mineralization is but little different from that which was on the south side before secondary enrichment made the latter of commercial grade. In time, as the methods of leaching and milling become improved, even this area may become of value as ore.

The ore in the granite porphyry on the south side is found under a very irregular gossan. Its commercial value stops in depth, where secondary enrichment has stopped. This line also is irregular, but it dips in general toward the east. Although no distinct zones of sheeting or breaks occur in the porphyry of Sacramento Hill, the main trend of minable ore is parallel to the Dividend Fault. One extension of this porphyry orebody has been down-faulted along a mineralized zone which extends into the limestone area to the south and into the rock north of the Dividend Fault.

Two porphyry orebodies, have been found, one of which is practically mined out; the other has two extensions, which branch off the remaining main body. The more southerly branch is several hundred feet deeper than either the main body or its northeast extension.

In speaking of the porphyry mineralization as separate orebodies, one must remember that it is done on the basis of their economic copper content. In reality, the whole porphyry stock would be considered an orebody if it could be mined economically, because it is thoroughly mineralized by disseminated sulphides and silicification. The more siliceous ribs, formed during mineralization, all but created a barrier between the two main orebodies, as there is only a narrow and more or less east-west band of porphyry ore between the West and East orebodies.

The erosion before and since Cretaceous times has uncovered such outcrops as are now visible. It is doubtful if the Bisbee district would have been found had this erosion not taken place. The inference is that other districts which have a large or even a small well-mineralized porphyry stock, such as Sacramento Hill, in a limestone country, may have orebodies in the limestone not yet discovered, or if erosion has gone too far, only the weak low-grade roots are left.

The generalizations given in the foregoing are not entirely applicable to every part of the district, and the following remarks give further details as to areas. Much has still to be learned about the conditions that result from mineralization at various elevations below the original surface at the time of mineralization, so that one may judge as to the position of the erosion surface one is studying with regard to the location of the kind and most intense mineralization.

THE Southwest-Uncle Sam-Shattuck area is the most westerly one. In it the ore occurs mostly in the Martin (Devonian) limestone, although sizable orebodies of sulphide have been found in the Abrigo limestone. One oxide orebody contained 1,250,000 tons of ore running better than 8 per cent. In the Shattuck, a copper-glance orebody of considerable size was mined, with cracks cemented together by malachite. The hypergene ore was of higher grade than in most of the other sections. Oxidation has enriched this still further by the removal of iron and sulphur. Sulphide orebodies are in the minority.

Quartz-manganese outcrops are long-distance guides, much as smoke is of a fire, and are above or to one side of the orebodies. These manganese outcrops have been mined for manganese to such an extent that they have constituted the most important source of manganese ore in Arizona. The manganese is hypergene, although a fair-sized low-grade alabandite deposit is found 400 to 500 ft. below the surface, near the surface exposure of oxide manganese.

Primary hypergene hematite is found as a gradational product from the silica to the ore, and below the ore the former siderite is altered to limonitic material, which, unable to support the weight of the orebody, was crushed, permitting additional settlement of the orebodies. The hematite contains some small amounts of gold and silver and traces of copper, and occurs in a large body up to 70 ft. thick. It is too high in silica to be mined for iron ore. This slumping is registered by calcite-incrusted caves and cracks leading out of them to the surface, where a distinct slumping has found expression in calcite-healed cracks.

The fact that primary oxides of manganese and hematite exist, and that the primary sulphides were higher in copper and lower in sulphur, indicates that one of the important periods of mineralization in this area was deficient in sulphur and that the native copper and copper oxide may well have been of hypergene origin.

In oxidizing, the orebodies shrink in thickness and caves are formed above them. When the orebodies settle, the caves become larger. Cracks from these disturbances reach the surface, and the whole process is called "oxidation slumping" by Wisser[1], and closely resembles mining subsidence caused by underground caving methods, with the difference that the cracks are healed by calcite which has the appearance of aragonite.

The ore in the Southwest occurs in the limestone with no relation to the granite porphyry, or, as in the Cuprite and Shattuck areas, intimately associated with it. In the former, it is a replacement of limestone due to solutions coming into breaks and intersecting breaks, and in the latter it has found its way into the limestone where porphyry has pinched and swelled, forming embayments as where a sill leaves a dike or where either a sill or a dike becomes thin or widens out, or on top or bottom of large flat sills.

Large and important deposits of lead carbonates have been found in this area, and the evidence indicates that the ore was deposited as galena, pyrite, and silica. The silica remained, the galena was oxidized to cerrusite, and the pyrite and most of its oxides were removed, leaving an iron-stained skeleton of silica and cerrusite which, owing to the pressure from above and the sides, broke down, so that most of the lead ore was found in layers not unlike loosely aggregated or irregular cross-bedded sand-

[1]Wisser, E. W.: "Economic Geology," Vol. 22, No. 8, Dec. 1927.

stone. Downward-moving solutions have caused mechanical sorting of the material in the caves containing the oxidized minerals, before the caves collapsed, and increased this effect of layers. These lead orebodies are closely related to a silicified roof which had been made of silicified limestone beds.

Slump calcite can be traced around the sides of these and other oxidized ore stopes, indicating the effect of oxidation slumping is transmitted into the sides as well as above the orebodies.

THE Czar-Holbrook area has been worked for fifty years. Some of the old records not being what they might, old gobbed stopes that are not mapped are frequently encountered. Very high-grade copper carbonates and beautiful specimens of malachite and azurite, as well as cuprite, have come from this area and have found their way into museums and collections. This section is exceedingly well mineralized, thoroughly oxidized, and has produced a great deal of ore, and in places 15 per cent of the volume prospected was found to be ore. In fact, a large part of the area for a depth of 200 to 300 ft. was a large, well-mineralized block cut by porphyry dikes, but oxidation differentiation made numerous orebodies. In this area gobbed stopes have been reworked several times, having been filled with what was formerly considered low-grade ore; also, since this is a very much broken-up country, downward-moving copper-bearing solutions in passing through the gob, whether it be of good grade or not, have enriched the gob so that it could be mined at a profit. Cuprite and malachite have been found which were formed in this manner during the last twenty years.

Several years ago, this section was reopened with the idea of working it out, but prospecting has developed a large amount of new ore, and the area has a bright future. Large and important ore reserves are contained in this block, and new ones will be found through development work.

The entire area may be considered as an orebody with rich, minable portions scattered through it. Geologic prospecting is difficult and is, at times, based on an indefinable rule that a certain block is too large to leave unprospected; hence it should be cut up by drifts and raises. Porphyry dikes where recognizable, and certain break zones whose trend has been developed by being stoped to some extent, are cut with the hope of finding extensions of ore. Ore, if found on one side of a dike, is sought on the other side by cutting through the dike. A mathematical means of prospecting has been proposed. It is based on determining the per cent of ore found in a given adjacent block and applying this figure to the block in question and computing the probable ore. If the amount thus ascertained will more than pay for the development work planned, work is recommended in the block. Guides to ore, though difficult to follow, are used most frequently, however.

Kaolinized limestone which has the consistency of stiff putty quickly crushes the drifts driven through it when left unrelieved and this plasticity is partly responsible for the scattering of the orebodies. As oxidation proceeds, and caves or openings are formed, the kaolinized limestone forces its way into these openings and drags its contained orebodies with it. Long before mining had been started, this process of shifting, kaolinized limestone had moved some of the orebodies out of relation to their guides. I do not mean to convey the idea that this sort of limestone is found everywhere in the area under discussion, but it is common, especially in the upper part of the mine and close to the granite porphyry, and is one of the contributing factors that makes prospecting so intriguing.

The ore is found mostly in the Cambrian and Devonian limestones, but also in the lower Carboniferous.

The Czar fault zone is an important solution channel, and post-mineral faulting has not been entirely solved. Hope is held that when it is, a fault block containing orebodies not yet found will be encountered. The whole area was originally much broken up and crushed, and many sills and dikes of granite porphyry entered between the blocks of limestone. Mineralizing solutions fairly soaked the limestone blocks, and oxidation finished the now almost complete alteration seen on the upper levels. Secondarily enriched sulphides and primary sulphides are found in the middle and lower levels in firmer ground, some of which is well silicified. The grade of some of the primary sulphide orebodies is very good, generally speaking, although barren sulphide orebodies are also found.

All of the workings are at comparatively shallow depths, and here, it is believed, will be found in depth a second zone of mineralization somewhere near the junction of the Czar and Dividend faults.

IN THE Gardner-Lowell area, a large percentage of the ore mined came from the contact-breccia zone. This zone is of variable width and is absent where the porphyry mass contacts with the limestone. Where the limestone was sufficiently broken up and the porphyry penetrated along breaks, the contact breccia formed as a layer between the dike walls and the limestone also.

The limestone fragments in the breccia were replaced by silica and sulphides of iron and copper, and the orebodies depend for their size on the size of the fragments, on the mine foreman, the grade which is economically minable, and the method of mining, because not uncommonly all of the stope walls are in waste at the same time and courage is required to blast through the walls to ore which usually is found just beyond. Reaching out after ore is necessary and is responsible for the rather good size of the orebodies.

HERE, as elsewhere, the granite porphyry plays an important part, as ore solutions certainly dropped their burden of ore where the porphyry made its embayments. It undoubtedly controlled the channels, because porphyry dikes have invaded the contact breccia and orebodies 600 ft. high and 200 to 400 ft. on a side have been and are being mined, closely associated with the porphyry along its contact with the contact breccia. This is not all minable or commercial ore, but the border-line ore has to be taken in order that no high grade be left behind. The average tenor of the body when mined is usually found to be above the minimum grade at which this type of ore can be mined at a profit.

Orebodies of considerable vertical extent are also found in the limestone along major wide break zones that are concentric to the porphyry mass of Sacramento Hill. The tabular orebodies usually found in limestone deposits are not entirely predominant.

It is characteristic of the orebodies of the Lowell area that they are strongest and most enriched, both primarily and secondarily, near the porphyry stock of Sacramento Hill and that the grade and size diminishes to veinlike primary sulphide orebodies as the distance from the stock increases. Boxwork siderite is used as a guide, and some areas of porphyry are sufficiently high grade to be mined as smelting ore.

In the Sacramento Hill area, one of the main orebodies was on the contact of the contact breccia zone with the porphyry where the breccia was mostly limestones which had been kaolinized to a large degree and extent. This orebody depended for its values on secondary enrichment of the sulphides. It was so waterlogged when found that it had to be drained, and even after it had been opened for years, the moisture content of the ore was often 17 per cent.

The mineralization of some porphyry dikes which were not very high in primary copper was enriched by secondary actions to a point where they could be mined profitably. Black sooty chalcocite was mined and stopes often looked like the face of a coal mine. Very high-grade ore was mined from this area, and one of the claims is credited with having produced more ore per acre than any other in the district.

The porphyry and the kaolinized limestone seldom lent themselves to alterations by the iron and acid solu-

tions of the secondary reactions that accompanied the enrichment of the sulphides, and, as a consequence, the limestones below and somewhat to one side were flooded by these solutions and very large and impressive masses of boxwork siderite were formed and are used as a guide to ore, although siderite is also formed from pyrite oxidation. In this area, also, clear examples of the close relation of the granite porphyry-limestone contact as a location for ores are seen. A large and important orebody was mined on both sides of the Sacramento dike for a width of 40 to 50 ft. on each side and for a length of 200 ft. The granite porphyry, known as the Sacramento dike, though it has a fairly definite strike and dip, is most irregular in thickness, and as it pinches and swells, abrupt embayments are formed, and in these embayments the limestone which has been broken previously is an excellent host of ore, and large and important orebodies have been found. Such embayments are sought and contacts are followed in search of them. These two guides to ore — namely, the boxwork siderite and the porphyry-limestone contact—are important, but there is another guide which is of some value, and that is the breaks parallel to the Junction fault zone. This fault zone itself, which contains and has contained important orebodies in the Junction mine of the Calumet & Arizona Mining Company, is not fully prospected.

A type of orebody common to this area and the Junction mine of the Calumet & Arizona company is one consisting of very dense, satiny pyrite with only about 0.5 per cent copper which has been well sheeted and has these openings filled by chalcopyrite, bornite, and primary chalcocite during a later period of mineralization.

In the Sacramento Hill area, as in the others, prospecting is being done by using all available guides and cutting up the country intelligently, but it is impossible to lay out regular preparatory workings in anticipation of extracting the ore of an orebody after it is encountered. The questions of grade, shape and size of an orebody are never known until it is mined out, and often an orebody is mined to its full size only when the price of copper is high enough to warrant its complete extraction. Here, as elsewhere, owing to the irregular shape of the orebodies, an unusual amount of stope preparation is necessary and systematic preparatory work is not possible. Of late, however, owing to the use of the diamond drill for delimiting the orebody when found, less preparatory work of drifting and raising is necessary.

In the Don Luis area the ore so far found occurs in the upper 150 ft. of the Abrigo limestone and is not associated with porphyry. It is mostly sulphide and occurs at the intersection of breaks that dip at 70 to 80 deg., and certain beds of limestone that dip in an opposite direction at 25 to 30 deg. Since the strike of the break zones is not parallel to that of the bedding, the ore deposited along the trace of the strike of the lime and the break zones is found to be plunging at about 15 deg. to the north. A long orebody is the result, because the maximum thickness of beds that are replaced is 25 to 30 ft. Orebodies 850 to 900 ft. in length are found.

The orebodies are frequently oxidized at their upper ends, and secondary enrichment effects are seldom great. In some occurrences the orebodies were primarily low in grade and have been enriched later in breaks running along their length by a second hypergene period of mineralization. Most perfect specimens of sulphide replacement of limestone in which the banding of the limestone is still remarkably well preserved come from this area.

Prospecting in this region is comparatively simple, and if it were not for normal faulting, the displacement of which is not always readily readable, it would be an ideal place to find ore. In drifting along a break, changes in dip and strike of the limestone are an almost certain sign that a zone of mineralization is being approached and is explainable by imagining what happens when limestone strata are slid past each other during faulting: one side is bent upward and the other down; but, more than this, before breaking takes place along a fault twisting at right angles to the strike of the break occurs and channels are formed which sometimes remain after faulting.

Although the orebodies are not very large, more extensive work will prove them rather numerous, and in the aggregate they will probably make of this somewhat neglected area an important part of the Warren mining district.

Ore guides in limestone may be summarized as follows:

Manganese as outcrops or along breaks as a far guide; above ore or to one side.

Silica, hematite, or both, closer guides than manganese; above ore or to one side.

Limonitic gossans, calcite-filled cracks (cemented or healed) over oxidized slumped orebodies are direct guides; the former are rare in the district, but the latter are found over the ore when present or over solution caves.

Caves encountered underground are caused by oxidation shrinkage of the ore and subsequent slumping, or by removal of limestone by downward-moving circulating ground water. The former is a near guide.

Boxwork siderite or its resulting limonitic oxidation is a guide upward, but is due also to barren sulphides.

Basic porphyry dikes at places of embayments along contact of dikes and sills with limestone on both sides of the dike.

Break zones with intersection of bedding, especially where the dip of the bedding is different from normal.

Mineralization on and along break zones often leads to orebodies.

A noticeable and remarkable feature of the porphyry orebodies is the very irregular top of the zone of secondary enrichment. The gossan frequently extends several hundred feet below the top of the enriched zone. In general, the ore dips toward the east, but frequent exceptions to this have been noted, and often there are two layers of high-grade, secondarily enriched ore with ore of lower grade between. In a certain case, one extension of the main orebody is several hundred feet below the main orebody, due to faulting. Under this extension is found a very irregular bottom of limestone breccia which has been partly altered to siderite by the iron solutions coming down through the porphyry. About all that the iron and acid solutions do to the porphyry as they pentrate it is to leach and koalinize the feldspars.

Water is found throughout the orebody in reservoirs which are not at any given elevation and are of various sizes scattered throughout the porphyry.

Because of the siltlike fineness of the material between the blocks of ore, and which is produced by the ore blocks made in block-caving and the kaolin which is present in the ore, the water is dammed off or back when mining operations are stopped for a while. This probably explains why the reservoirs of water described are found.

The churn drilling which showed the values to be exceedingly variable was done on the corners of squares 100 ft. on a side. This variability occasioned some concern, but on mining it was found that the estimated tonnage and grade checked the actual tonnage and grade remarkably well.

The following speculations are offered Warren mining district was found because of its outcrops, although its extent could never be judged by them, and its presence would probably not have been suspected by anyone who had bee nhere say 50,000 years ago What did the silicified oxidized gossan of Sacramento Hill, which was probably at a greater height than now, then look like? Would it have contained hints of the ore which lay hidden below and on the sides of the porphyry stock?

There are several reasons to believe that the Cretaceous did not cover all of the formations in the Mule Mountains in which Bisbee is situated. Some of the high peaks must have been above the Cretaceous during and since this period.

The Dividend Fault in its present

position is a normal fault, but if the geology be reconstructed one finds that, by bringing the Carboniferous and earlier rocks to a vertical position, the Dividend Fault was an overthrust fault, which conforms to the belief generally held that the major faults of disturbed formations are overthrust, although this is not always provable, because such a thrust fault, being recessional, often appears in its final resting place to be a normal fault.

In the district, the ore mineralization is found higher in the geologic strata to the east than in the west, but since the general dip of the strata is to the east and at a steeper angle than the trend of mineralization, the ore also is found deeper below the present surface in the east than in the west. It is a question at what depth the ore will be found at its extreme depth in the east and whether it will be economically worth while to get it.

Sacramento Hill is the only known important center of mineralization. In a district as large as this, is it not possible that another Sacramento Hill is hidden from view by limestones? If it could be found it would be a very valuable addition to the district.

Replacement of limestones by sulphides has made the district important as a copper camp. Is it not possible that ore can be found in the quartzite? There are other mining districts where the quartzite is productive of copper ores.

A study of the geologic map makes one wonder what became of the half of the mineralized limestone ring that lay north of Sacramento Hill, but which has been eroded. Was it ever there, and, if so, is not a portion of it buried under the Cretaceous formations?

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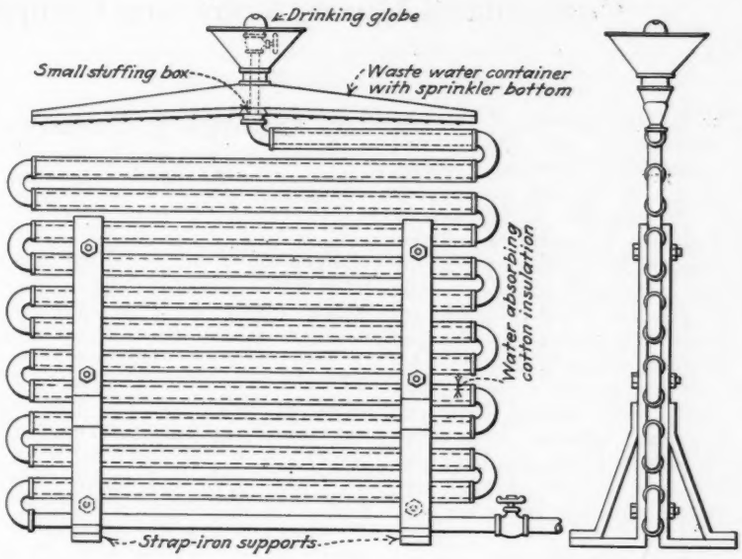
Drinking Fountain Provides Cooled Water

A SIMPLE and economical method whereby cool drinking water can be provided for surface employees is shown in the accompanying sketch, which illustrates a fountain developed by John Langdon, master mechanic, United Verde Extension. The unit was installed for experimental purposes at the company's mechanical department situated at Clemenceau, Ariz. Construction of the apparatus consists of a pipe coil bolted onto two strap-iron supports, a waste-water container with sprinkler bottom and a small stuffing box, and a drinking globe. All pipes are wrapped with water-absorbing cotton material, which is constantly kept moist by the excess water collected in the waste-water container and distributed through the sprinkler bottom. The best results were obtained when the fountain was placed in an open, shady place, where advantage could be taken of the prevailing air currents.



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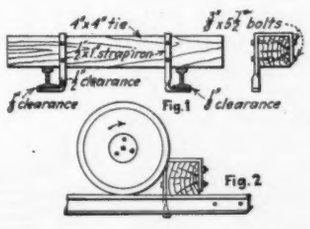
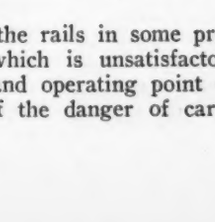
Stop Tie for Dump Tracks

THE stop or bumper tie on waste-dump tracks must be moved frequently with the advancement of the dump, writes E. W. Baker, mechanical engineer, Hope Metals Company, Winkelman, Ariz. Ordinarily, a common tie is wired, tied with a rope, or bolted to the rails in some provisional manner, which is unsatisfactory from a safety and operating point of view, because of the danger of cars falling over the dump, and the time required to move the bumper. The fixture described here, consisting of a sound tie and two bolted-on brackets made of ½x1-in. strap iron, is safe and can be removed and adjusted in a fraction of a minute. As shown in Fig. 1 of the accompanying sketches, a ½-in. space is allowed between the rail base and the brackets, and a clearance of ⅛ in. between the flat hook-like bracket ends and the rail bottom, to facilitate the turning and a quick removal of the stop tie. The operation is simple. The tie is first placed on the rails at an angle to permit slipping of the flat bracket ends between the two rails, and then turned to a position parallel with the rail ties. To avoid slippage, the bracket ends anchoring the tie to the rails should always face the car wheels, as illustrated in Fig. 2.





Consolidated's Zinc, Acid, and Fertilizer Plants

Fourth of a series of articles on the technical operations of Consolidated Mining & Smelting Company of Canada, Ltd.

George J. Young
Associate Editor

THE total capacity of the zinc division of the Consolidated metallurgical plant at Tadanac, B. C., is now 400 tons of zinc per day. Of this, 300 to 350 tons is derived from the treatment of sulphide concentrate, and 50 to 100 tons from the new oxide treatment plant recently placed in operation. Two products are made: Grade A, or electrolytic zinc, and Prime Western, which is made by adding the requisite amount of lead, about 0.8 per cent, to the molten electrolytic zinc. Zinc-plant residues have accumulated to such an extent that over one-half million tons are now on hand, containing 20 per cent zinc and 9 per cent lead.

Consolidated's sulphide plant consists of roasting and leaching departments, the former containing 25 Wedge furnaces, 25 ft. in diameter, seven hearths, and each furnace handling from 36 to 38 dry tons per day. About 800 dry tons of zinc concentrates are handled daily. This material is roasted down from 33 to 3 per cent sulphur, the 3 per cent being partly sulphide and partly sulphate. The reduction of weight in roasting is about 8 per cent. Experiments are now under way that may be expected to result in a radical change in roasting practice.

The process of zinc extraction has not undergone any material change recently. In this, the continuous double cycle is followed. The whole tonnage of calcine is agitated in pachucas, with the acid thickener overflow, which insures complete neutrality of solution and the removal of soluble iron. This is a purification step, as all the arsenic and antimony, if not in too large quantities, are removed with the iron as it is precipitated out of solution. The mixture of solution and calcine, after thorough agitation in the neutral pachucas, passes to classifiers, which remove the sand. Then the sand is sent to a ball mill, reground, and pumped to the acid pachucas. The classifier overflow passes through distributors to Dorr thickening tanks and to Genter thickeners, the spigot products of which go to the acid pachucas. Overflow and Genter filtrate enter the purification circuit, where zinc dust is added.

After treatment, the product is discharged into a thickener, the underflow from which passes through a filter box which removes the precipitate (for the cadmium plant), the filtrate returning to the thickener. Overflow from the thickener passes to a surge tank and thence to Kelly filters, which remove the suspended material (for the cadmium plant). The clear solution is pumped to storage tanks and drawn off to the electrolytic department as required. Part of this zinc-bearing solution is bypassed for purification of cobalt before pumping to the storage tanks.

To the acid pachucas are added the return acid (135 grams free sulphuric acid per liter) from the electrolytic department, the neutral thickener spigot product, the acid solution after leaching of the melting-furnace dross and the ball-mill product. After treatment the pulp is sent to a distributor, which divides the flow between the acid thickeners. The underflow from the acid thickeners is pumped by diaphragm pumps to a group of seven American filters on which the residue is washed and removed. Woolen bags on coco matting form the filtering surface. The filtrate and washings are sent to the neutral pachucas along with acid thickener overflow solution. The residue, which contains some soluble zinc as sulphate, insoluble zinc, iron, and lead, is sent to a storage dump and eventually to the lead-smelting circuit. Fig. 1 shows steps in the sulphide treatment.

The oxide plant receives the oxide fume from the slag-fuming treatment, and also the lead-blast-furnace flue dust. Fig. 2 illustrates the method of acid treatment, which is similar to that used in the sulphide circuit. The receiving bin holds 5,500 cu.ft. of oxide product. Traylor vibrating feeders discharge it into a screw conveyor, and this in turn into two puggers, which also receive acid solutions from the electrolytic department. The puggers, equipped with Minerals Separation propellers, are to be replaced by a 5x8-ft. mixing tank. Only sufficient solution is added to form a pulp, which is pumped, by one of two centrifugal pumps, to the acid pachucas, of which there are five, each 10x30 ft., lead-lined. Sufficient acid is added to dissolve the zinc, and a small amount of iron solution is also added. Oxidation is effected by aëration. As each batch is finished it is run to the acid Dorr thickeners, of which there are three, 50 ft. diameter by 15 ft. deep, Douglas fir tanks, gunite cones in bottom, 3-ft. fall to center. The underflow from these comprises the lead residue, which goes

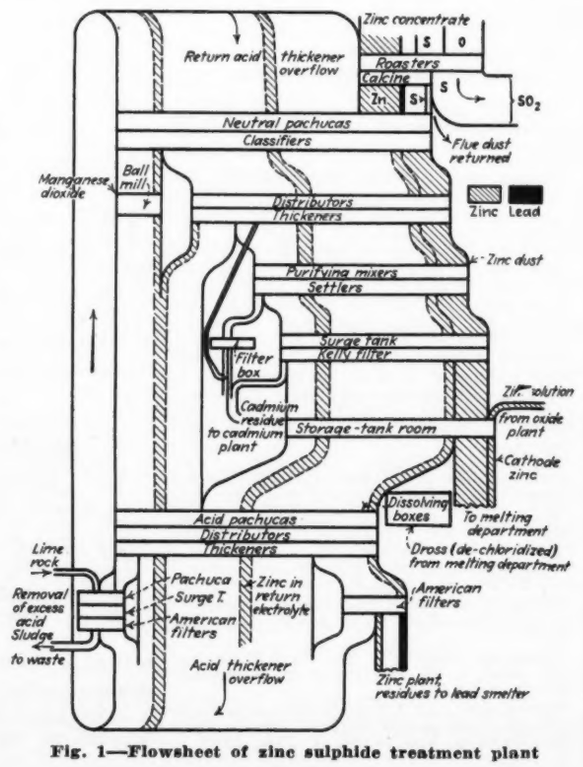


Fig. 1—Flowsheet of zinc sulphide treatment plant

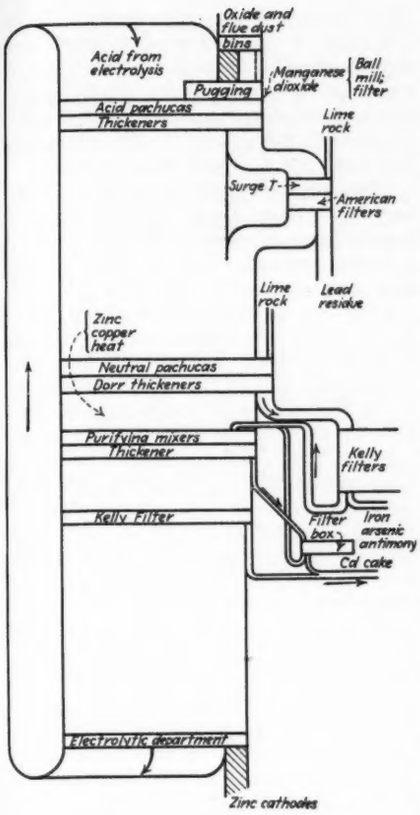


Fig. 2—Flowsheet of oxide zinc plant

to a surge tank. Here it is neutralized with limerock and then flows to two American filters, the cake discharge going to the lead smelter and the filtrate, along with the acid thickener overflow, to the neutral pachucas. This residue is about 20 per cent of the oxide.

The overflow of the acid thickeners is sent to four 10x30-ft. neutral pachucas, neutralized with roaster calcine, and agitated before going to the two 50x15-ft. neutral thickeners. The acid overflow contains all the zinc and impurities, such as arsenic, antimony, copper, cadmium, and cobalt, as well as a small excess of acid and iron. Neutralization throws down iron, arsenic, and antimony. As each successive batch is sent to the neutral Dorr thickening tanks, the underflow passes to four Kelly filters. The filtrate is pumped to the purifying mixers. These comprise six 10x16-ft. tanks, with closed tops and equipped with mechanical agitators, where zinc dust is added and heat is applied, for the precipitation of cadmium, copper, and cobalt. The solution batch is discharged into a 20x12-ft. Dorr thickener, the underflow of which is pumped by a diaphragm pump to a vacuum filter box, the overflow going to a 5x14-ft. Kelly filter. Precipitate from the vacuum box and from the Kelly filter goes to the cadmium plant for further treatment. At this stage the solution is sampled. If it meets requirements it is pumped to the electrolyte storage tank.

The vats used for purification have wooden stirrers, operated at 40 r.p.m. by 5-hp. back-gear V-belt-drive motors. The battery of four Kelly filters (ten leaves) operates at 40-lb. pressure, supplied by a 4-in. Morris pump. A Canadian General Electric turbo-blower supplies 4,000 cu.ft. free air per minute at 25-lb. pressure and 170 deg. C. for the pachucas. Five Antisell lead pumps are used for handling solutions and pulps free from grit. For other pumping service, centrifugals are used. The building is of steel-frame construction, with gunited side walls, and a floor deck of 2x4's placed on edge.

All zinc sulphate solution is delivered to three houses that contain 2,340 cells, each containing 24 lead anodes and 23 aluminum cathodes, the anodes being spaced at 3-in. centers. Current density is 46 amp. per square foot and voltage drop between cells 3.6. The electrolyte contains 150 grams zinc per liter, and the acid electrolyte, 135 grams free sulphuric acid per liter. About 65 per cent of the zinc in solution is deposited. Cathodes are removed and stripped each 24 hours.

Anode mud, of manganese dioxide and lead oxide, is removed from the vats at intervals and stored or returned to the ball-mill circuit in the leaching plant. Electrolytic vats, in pairs, are made from reinforced concrete painted inside and out with asphalt paint and lined with a sulphur-sand mixture cast in place. The sand mixture is used to prevent corrosion. These vats last five or six years though half of them have been replaced in three years. Direct current for precipitation is supplied by thirteen sets of motor-generators (26 generators) 1,100 kw. per set; ten synchronous rotary converters of 2,600 kw. each and three mercury-arc rectifiers each of 5,500 kw.

Cathode zinc is delivered by hand-trammed trucks to the melting department in a contiguous building, where it is charged into 100-ton reverberatories through openings in the top arch. After melting, the zinc is hand-ladled to the molds. Drosses are collected and heated in a separate furnace, to expel ammonium chloride, and are then sent to the zinc plant for dissolving in acid.

Cadmium cake is dissolved by sulphuric acid in vats that are equipped with mechanical stirrers. The solution is filtered by Kelly filters, and the cadmium precipitated by zinc slabs suspended in the vats. The cadmium sponge is gathered at intervals, washed, and redissolved in sulphuric acid, filtered by Kelly filters, and then electrolytically deposited. Cadmium cathodes are melted and cast into bars, pencils, and balls. Solutions from the first cadmium precipitation are sent to the zinc-leaching plant and those from the cadmium electrolytic deposition are used for dissolving the cadmium sponge.

The Dwight & Lloyd roasters, lead blast furnaces, and the zinc roasters are provided with Cottrell treaters. An interesting feature of inlet and outlet flues and treater construction of the D. & L. roasters is the use of laminated 2x4 wooden lining. Walls are of wood pieces 2x4 in., doweled and gunited on the outside over chicken-wire netting. All structural steel, on the outside, is protected by lead at bearing points. The top decking of the flues is laminated 2x4-in. wood. The top of the treater section is steel plate. Wooden walls are used in the treater sections, and these walls are lined with sheet lead. The treater, of the plate type, consists of four sections in series and seven parallel units. Plates are 10x10 ft., $\frac{1}{8}$ in. thick, with vertical corrugations. The vertical wires are placed in the maximum spaces between the corrugations of contiguous plates, which are placed so as to have depressions opposite depressions and "anticlines" opposite anticlines. Plates are at 8-in. centers; vertical wires at 5 in. centers. Wire electrodes are suspended below the tops of the plates, making all of the space effective. The purpose of the wooden lining is to secure a surface that will resist the corrosion resulting from condensation, as humidification is necessary. The humidifying flue is of concrete, lined with 2x4 laminated walls, and has a wooden top decking of the same material.

Lead blast furnace treater units have both plate- and pipe-type treaters. The plate type has four units in parallel, with 12-in. spacing of plates; the pipe type has eighteen sections, 32 12-in. pipes to the section, also operating in parallel. Flue walls are of brick. A reinforced concrete stack 25 ft. in diameter and 400 ft. high serves the sintering plant, and one 18 ft. diameter and 250 ft. high serves the lead blast furnaces.

The gaseous products of the Wedge roasters in the zinc plant are handled by three treater units, each with four sections in series. Plates are spaced 12 in. apart and are 10 ft. long by 12 ft. deep. Flue walls are of gunite on structural steel. Treater section walls are gunite on both sides of structural steel. A reinforced-concrete stack, brick lined, 21 ft. diameter by 400 ft. high, serves the flue system.

A plate-type treater is in use at the gold and silver refinery for handling the arsenic and antimony fume. At the contact acid plant a plate-type treater is used for cleaning hot gases. In addition, a pipe-type treater is used for mist precipitation, both being in the flue circuit.

At present 22 rectifier machines of 25-kw. capacity supply current for the Cottrell treaters. Each machine takes about 15 kw. Treaters on the blast-furnace circuit retrieve about 40 tons of dust per day; on the sintering furnace circuit 15 to 20 tons; on the zinc roasters about 60 tons; at the silver refinery 2 to 3 tons of antimony dust; and at the acid treaters 1 to 1½ tons

of dust is normally precipitated every day.

Sulphuric acid is used in the zinc circuit, in the lead electrolytic refinery, in the preparation of hydrofluoric acid, in the oxide plant, and in the gold and silver refinery. Formerly a lead-chamber acid plant supplied the needs of the various departments, but this has been displaced by a 35-ton contact acid plant, which receives a flue gas containing about 6½ per cent sulphur dioxide by volume from the zinc roasters and produces a 96 per cent sulphuric acid. This plant uses platinum contact masses. Additional contact acid plants are now being constructed which will take zinc roaster gases and produce 375 tons of 100 per cent sulphuric acid per day. This acid will be pumped to storage tanks at the fertilizer plant recently completed.

The comparative isolation of the Trail plant created the necessity for repair shops, so these have been progressively developed. Company policy provides for making practically all of its machinery with the exception of electrical motors and highly specialized equipment. The rights to manufacture this machinery are purchased from American and Canadian firms. In consequence of this policy the shop equipment is unusually complete. The floor area of the principal shops in square feet is as follows: boiler, 15,350; welding, 2,100; blacksmith, 3,000; machine shop, 22,600; foundry, 13,250; pipe, 3,600; and warehouse, 22,526. A woodworking shop as well as a number of smaller special shops are also provided.

For handling custom ores the company has a lead-ore sampling mill, a copper-ore sampling mill, and a 600-ton concentrator. A 100-ton per hour crushing plant equipped with jaw crushers and rolls is an accessory to the concentrator.

Warfield Flat, a higher terrace overlooking that upon which the metallurgical plant is built, has for the last year or so been the scene of an intensive construction campaign having for its objective the completion of a sufficient number of the parts of a $10,000,000 fertilizer plant to begin the manufacture of fertilizers in 1931. A considerable amount of preliminary experimentation was carried out at Tadanac, and S. G. Blaylock, E. M. Stiles, and R. W. Diamond fully investigated European practice. The new plant has been constructed on the basis of a fully equipped commercial plant of considerable size. It occupies an area of 60 acres on a plant site of 165 acres. The principal parts are as follows: an electrolytic hydrogen unit consisting of Knowles-Fauser Pechkranz and Stuart cells (900 cells, 10,000 amp. each, requiring 21,000 kw.) for the production of 3,000,000 cu.ft. hydrogen per day along with a byproduct of oxygen, the hydrogen being received in a gasometer; a Claude liquid-air unit for the production of nitrogen which will be stored in a gasometer; a Fauser synthetic ammonia unit, which will receive the mixed hydrogen and nitrogen gases from a mixed-gas gasometer and convert the mixture into anhydrous ammonia gas; production of anhydrous ammonia (about 47 tons per day) to be refrigerated and stored under atmospheric pressure in tanks, the vapor evaporating being sent through a refrigerating machine and retrieved to its tank storage; conversion units consisting of Brown-Boveri and General Electric mercury-arc rectifiers, each 650 volts and 10,000 amperes; a strong-acid process unit for making phosphoric acid, which is being built by The Dorr Company; fertilizer manufacturing units and a concrete-steel fertilizer storage house, 80x500 ft., with shipping facilities and capable of storing 50,000 tons of commercial fertilizers; and an open-air phosphate-rock storage served by a conveyor system.

Buildings will be of brick and steel, and the arrangement provides for streets and parking spaces. The buildings erected and in use last year were a central office building, routine laboratory, soil laboratory, a warehouse, carpenter shop, machine shop, change room, and substation.

The plant as a whole will require about 25,000 kw. of power and will be supplied with process steam from the waste-heat boilers at the slag re-treatment plant through a 12-in. welded steam line. It is planned to make only highly concentrated fertilizer products such as mono-ammonium phosphate, triple superphosphate, and some ammonium sulphate. A source of supply of phosphate rock has been found and is being developed near Fernie. It is expected that about 450 tons of phosphate rock will be utilized and 175 to 285 tons of finished product made per day, depending upon the proportions of triple superphosphate and mono-ammonium phosphate made. Ammonium sulphate to the amount of approximately 100 tons per day will also be made.

This great chemical plant in the making has arisen from the necessity to reduce smelter smoke damage to proportions corresponding to what it was before the expansion that took place following the adoption of selective flotation. The fertilizer installation is planned to make use of sufficient sulphuric acid to call for the utilization of about 30 per cent of the sulphur dioxide now being discharged into the atmosphere. The great expansion in plant thus brought about required not only technical ability of a high order for its accomplishment but also considerable courage on the part of the management and directorate of the company to finance it.

Tadanac was one of the pioneers in zinc hydrometallurgy and initiated electrolytic lead refining. Likewise, it led the world in selective flotation as applied to the treatment of "complex" lead-zinc ores. Its lead-smelting practice has been consistently advanced until it is now in a leading position. Mr. S. G. Blaylock has shown wisdom in the selection of his operating staff and technicians. He and his associates have taken advantage of improvements in mechanical equipment and technology elsewhere, but Tadanac has also made its contributions to the advance of industrial technology. There is thus an interchange of experience which reflects credit to the mining industry of Canada and America and to chemical technology in general.

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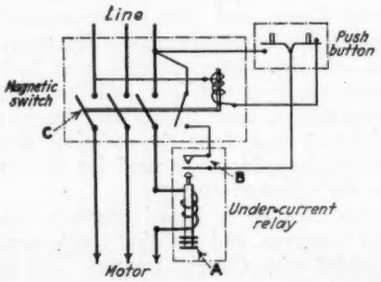
Automatic Switch Controls Centrifugal Pumps

CONSIDERABLE trouble was experienced at the smelter pump station of the Compagnie Du Boleo, at Santa Rosalia, Mexico, with seven hand-controlled centrifugal Sulzer pumps, discharging the water, drawn from a common sump fed by the ocean, into three elevated storage tanks, whence it flows by gravity to the slag-granulating plant, writes P. Perrin, assistant chief electrician. The receding tide frequently caused the water in the sump to fall below the lowest level; as a result, without warning, pumps would run idle. This resulted in overheating of the pump unit, causing undue wear of pump parts and burning out of motors. Successfully to overcome this difficulty called for the installation of locally designed automatic-control switches, a wiring diagram of which is shown in the accompanying sketch. The scheme of operation is as follows:



When pressing the push button, the magnetically operated plunger *A* of the undercurrent relay closes the contacts *B*, which in turn actuates the switch *C*, starting the pump motor. In the event of a sudden drop in amperage or pump load, the plunger *A* drops instantaneously and releases the contacts *B* and switch *C*, automatically stopping the pump running idle.

Edward Koepel

Flotation of Native Copper at Freda, Mich.

IN 1928 A. W. Fahrenwald, concentration expert for the U. S. Bureau of Mines, demonstrated in the metallurgical research department of the Michigan College of Mining and Technology that native copper in the amygdaloid veins of northern Michigan could be successfully treated by flotation when ground to minus-35 mesh. Following his discovery, the Champion Copper Company, a subsidiary of the Copper Range Company, like other operators in the district, considered addition of Fahrenwald flotation machines to the stamp-mill equipment to treat that portion of the material that was classified and suitable for such treatment.

In planning the remodeling of the stamp mill to incorporate flotation a flowsheet was developed that was a radical departure from former practice. Theretofore the stamp-mill and roll product was separated into several portions by hydraulic classification and each treated separately. Usually a concentrate, a middling, and tailing to waste resulted. Two-thirds of the stamp product was treated on variable-motion jigs and most of the tailings were reground in ball mills and then treated on tables. The hutch product from the jigs was tabled and the tailing reground in ball mills.

One-third of the stamp product, or about 200 tons per day, consisted of primary slime and fine material. This was separated from the coarser particles of ore by six four-spigot, trough, hydraulic classifiers. All of the water of classification, plus water introduced at the stamp, went with this slime. This large quantity of water originated from the following sources:

	Gal. per Day
Feed pan	13,000
Stamp-shaft urn	300,000
Hydraulic mortar discharge	137,000
Total added at stamp	450,000
Water for hydraulic classification	500,000
Total water with primary slime	950,000

A dilution of 20 to 1 resulted. This water and the suspended solids went to a large V-shaped settling tank, with a surface area of 12x40 ft., with an overflow along two sides and one end. The coarser portion, or about half the solids fed to the tank—namely, 100 tons—was withdrawn by raising plugs in the bottom, and treated on tables. The remaining 100 tons, diluted 40 to 1, went to waste with the overflow to the lake as tailing, without having been treated at all. The solids so lost were all minus-200 mesh, and would remain in suspension for a long time. This material carried from 3 to 6 lb. of copper per ton (0.15 to 0.3 per cent), depending upon the richness of the ore stamped.

This loss from the V-tanks was not the only loss of this nature, however. Nearly every treatment in the flowsheet required some settling, and each of these overflows entailed a loss of valuable fines, the total being of serious importance. A total of 33 tons of water per ton of ore was used in this flowsheet.

In applying flotation, simply to thicken these overflows to a suitable dilution was not feasible. Tests showed that the fine slime remained so persistently in suspension that the required thickener area would have been prohibitive. It was necessary, therefore, to prevent the dilution from occurring at the beginning of the operation. The first step was to accomplish the sand-slime separation mechanically, with a Dorr classifier, rather than hydraulically. Even that was not sufficient, however.

In the old practice, 450,000 gal. of water per day was added in the stamp mortar, to splash out the crushed material through the mortar screens, high-carbon steel plates punched with $\frac{5}{8}$-in. holes. So after cutting out the 500,000 gal. used in hydraulic classification, there was still too much water for flotation.

To obtain the 450,000 gal. of water required in the mortar, and at the same time avoid excessive dilution, about half of the primary slime, separated out by the Dorr classifier, was cut out and pumped back to the stamp mortar to furnish the necessary volume for splash purposes. The fresh water still added at the stamp-shaft urn was introduced in such a way as to wash the slime down the stamp-shaft and prevent it from creeping up and scoring the brasses. With these changes, the amount of fresh water used in the stamp and primary

Dorr thickener and filter for flotation concentrate

Grinding bay in the Champion mill at Freda

classifier became, in the new flowsheet, as follows:

	Gal. per Day
Feed pan	13,000
Stamp-shaft urn	100,000
Hydraulic mortar discharge	137,000
Elevator buckets and wash water on Dorr classifier, about	50,000
Total fresh water added with primary slime	300,000

The resultant primary slime is about 17 per cent solids, and is all added to the ball-mill discharge, being required to furnish the necessary dilution for classification in the closed-circuit grinding classifier, and to furnish also an overflow as a flotation feed which carries about 26 per cent of solids.

To use a Dorr classifier, instead of hydraulic classification, was entirely feasible, because a final tailing was no longer to be made from the jigs, but all the material was to be reground and sent to a flotation machine. Therefore, to classify the jig feed closely as to size was no longer necessary. This first concentrating step in jigs becomes essentially a roughing operation for the recovery of as much free copper as possible. This is important in the district here under discussion, since the metallic copper is malleable and difficult to reduce in size in a ball mill.

The treatment of an unsized feed in jigs, in several of the plants in this district, with regrinding of the jig tailing, has made possible the use of fewer jigs, requiring correspondingly less attention, less power, less maintenance, and much less water.

At the Champion plant the old jigs were replaced by concentrating tables, with the result that almost every detail of the operation has become visible. The concentrates are now delivered continuously, and, by cutting and recirculating a somewhat larger middling, variations in the rate of feed are taken care of; furthermore, the concentrate is kept up to grade and little free copper escapes with the tailings which are to be reground.

In the new practice, therefore, one unit of which is shown in the accompanying flowsheet, the material from the mortar, all minus-$\frac{5}{8}$-in. round hole, goes to trommels or electric vibrating screens. Everything plus $\frac{3}{16}$-in. goes to a rougher jig, making concentrate and tailing, the tailing remaining in closed circuit with the stamp mortar and the trommels or screens. The 280,000 gal. of water used in this rougher jig operation passes out to waste. All minus-$\frac{3}{16}$-in. materials, together with all the water from the mortar, is classified in a 3 ft.x18 ft. 4 in. Model SSD Dorr simplex classifier. As stated before, the overflow is split into two parts, one-half being pumped back to the stamp mortar, and the other half flowing by gravity to the discharge end of the ball mill.

Classifier sand is split for treatment on six tables, sufficient new water being added to each portion to flush it to the tables. These tables make a concentrate, middling, and tailing. Middling is kept in a closed circuit with the table feed so that ultimately nearly all of the free copper goes into the concentrate. Tailing is conducted to a dewatering wheel from which the sand is carried to the ball mill at about the same density as it comes off the simplex classifier. The clear water used for table treatment—namely, 300,000 gal.—goes to small settling tanks before passing out to waste.

The ball mill and its unusual motor drive require some explanation. Motors, herringbone gears, and such parts as could be used were salvaged from the old single-pass ball-mill installation, and a new mill was designed as large as two of the old motors could drive. A Falk reduction gear with a large pinion was chosen so that the old herringbone cut-gear could be utilized for the additional power required and for the slowest speed desired. The weight of the new ball mill was reduced to a minimum by using $\frac{7}{8}$-in. steel plate for the body and ends; furthermore, to secure rigid construction with light

weight, the ends were formed into 60-deg. cones. Lake Shore Engine Works, of Marquette, Mich., designed and built a self-aligning roller bearing, a picture of which is shown. This is 24 in. inside diameter and carries a load of 50 tons per unit. The view shows the inner ring extended beyond the cage holding the roller, which projects beyond the outer ring that is pressed into the cast-iron retaining ring. This, in turn, rests inside of the bearing and cap. Use of this bearing enabled us to utilize 6 per cent more of the power of the electric motors for grinding, with the following results:

One 8-ft.x54-in. ball mill with a load of 32,000 lb. of 2½-in. and smaller balls, driven at 24 r.p.m. by two Westinghouse squirrel-cage motors, taking 100 kw., in closed circuit with an 8-ft.x26-ft. 8-in. Dorr Duplex classifier, Model DSD, set at 3½-in. per foot slope, grinds 525 tons of feed, all minus-$\frac{3}{16}$-in., of which 33 per cent is minus-35, to flotation machine feed, 5 per cent on 48 and 55 per cent through 200. In the old single-pass grinding circuit, two 8-ft.x30-in. ball mills and one 6-ft.x30-in. mill ground a like tonnage of sand to 4 per cent on 20 and 30 per cent through 200 mesh. The 6-ft.x30-in. mill used a 25-hp. motor, and each of the two 8-ft. x30-in. mills used one motor of the same size as the two motors which now drive the 8-ft.x54-in. mill. Increased grinding efficiency is due to the closed-circuit grinding and also to the better mill adjustments, such as density of pulp in the mill (78 per cent solids), size of balls (2½-in. maximum), quantity of balls (32,000 lb.) and mill speed (24 r.p.m.), compared with the former speed of 27 r.p.m. for 8-ft. mills.

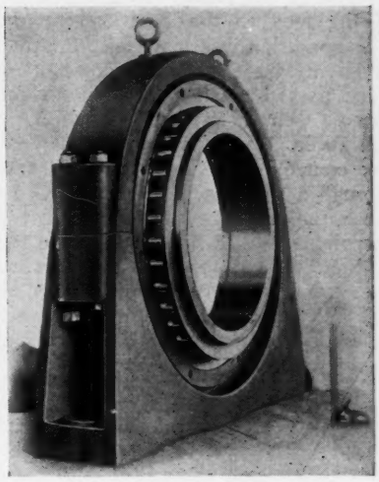
Overflow from the 8-ft. classifier passes to a 10- or 12-cell Fahrenwald "Sub A" 24-in. flotation machine making concentrate and tailing. The flotation tailing passes to a Dorr 6-ft. bowl classifier making a final slime tailing to waste and a sand product for regrinding in closed circuit with a Dorr 12-ft. bowl classifier. Two regrinding circuits are installed, there being six primary circuits. The classifier overflow passes to an eight-cell Fahrenwald "Sub A" 18-in. flotation machine, making concentrate and tailing. Part of the tailing passes over a pilot table, for inspection, and the remainder goes directly to waste.

Flotation concentrates from three primary units and one regrind unit go to a 30x10-ft. Dorr continuous thickener, and the thickened product goes to a Dorrco 6x4-ft. filter. The mineral is discharged from the filter with 10 per cent moisture and goes to the bins for shipment to the smelter.

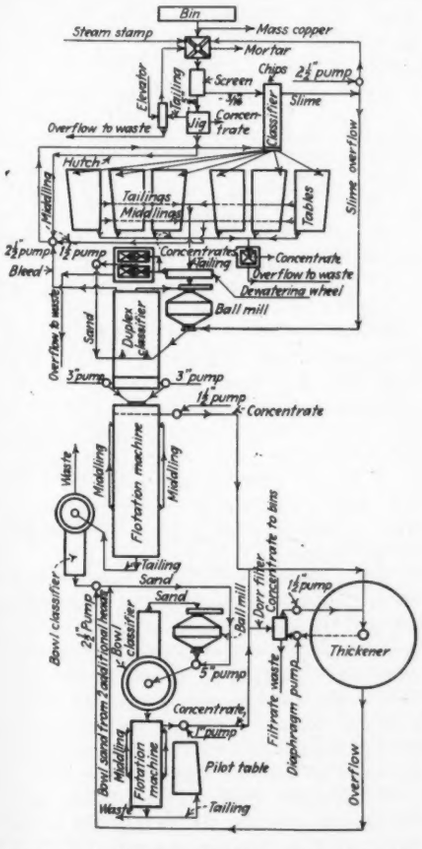
Operating data showing the disposition of the load and the results obtained from the different units in the flowsheet are given in Table I.

The nature of the grinding done by the 8-ft.x54-in. ball mill loaded with 32,000 lb. of 2½-in. balls is shown by the data in Table II.

The first completed unit in which the new flowsheet was incorporated went into commission in September, 1929. Three other units have since been remodeled to the same flowsheet. It was soon found that the tonnage of crushed material and water discharged from the mortar of the steam stamp was affected somewhat by the character of ore fed to the stamp, but the entire operation was affected more when the opening of the mortar discharge was clogged or partly clogged by big nuggets of copper, which caused irregularity in the density



Roller bearing used in ball mills



Flowsheet of the remodeled mill at Freda, embodying flotation

Table I.

	Tons per 24 Hr.
Ore per stamp	525
Slime from primary classifier	157
Sand from primary classifier to six tables	368
Middlings from six tables	40
Cut from closed-circuit classifier	85
Treated per table	82
Table tailings to 8-ft.x54-in ball mill	485
Circulating load in duplex classifier	1,400
Feed to flotation machine, 5 per cent on 48	500
Tailing to waste from 6-ft. bowl classifier	400
Classifier sand to regrind unit	100

	Pounds of Copper per Ton
Feed to flotation machine	10.42
Tailing from bowl classifier	1.31
Feed to regrind unit	4.25
Tailing from regrind flotation	1.17
Mill recovery, per cent	95.78
Ball load for one 8-ft.x54-in. ball mill, lb	32,000
Power required for one ball mill, kw	100

Table II.

Table Tailing
Feed to Ball Mill

	Mesh	Per Cent	Per Cent, Cumulative
On	6	3.8	3.8
	8	3.0	16.8
	10	14.3	31.1
	14	11.9	43.0
	20	10.7	53.7
	28	8.9	62.6
	35	11.0	73.6
	48	9.6	83.2
	65	7.0	90.2
	100	3.8	94.0
	150	2.2	96.2
	200	1.0	97.2
Pass	200	2.8	100.0

Tailing to Waste
Overflow 6-ft. Bowl Classifier

	Mesh	Per Cent	Per Cent Cumulative
On	35	0.0	0.0
	48	1.9	1.9
	65	5.0	6.9
	100	7.9	14.8
	150	7.3	22.1
	200	8.5	30.6
Pass	200	69.4	100.0

Feed to Flotation Machine
Overflow Duplex Classifier

	Mesh	Per Cent	Per Cent, Cumulative
On	35	0.5	0.5
	48	4.8	5.3
	65	10.8	16.1
	100	11.7	27.8
	150	9.1	36.9
	200	8.7	45.6
Pass	200	54.4	100.0

Bowl Classifier Sand to Regrinding Mill

	Mesh	Per Cent	Per Cent Cumulative
On	35	13.7	13.7
	48	35.9	49.6
	65	29.5	79.1
	100	12.7	91.8
	150	4.4	96.2
	200	1.8	98.0
Pass	200	2.0	100.0

Feed to Regrind Flotation Machine
Overflow of Regrind Bowl Classifier

	Mesh	Per Cent	Per Cent Cumulative
On	65	2.3	2.3
	100	9.7	22.0
	150	16.4	28.4
	200	16.0	44.4
Pass	200	55.6	100.0

of the feed to the flotation machine. This condition was materially improved by having the feed to the flotation machine pass through a box with a deep narrow weir or vertical slot ¾ in. wide and 20 in. deep. A float in the weir box controlled the admission of water through a valve in the water line. Because the weir in the box was very narrow, any little reduction in the feed to the flotation machine also lowered the surface in the weir box a little, but the float-controlled valve admitted enough water to maintain the surface of the material in the weir box at a substantially uniform height, thus maintaining a practically constant volume of feed to the flotation machine until the trouble at the mortar was corrected.

The practical results of the application of this new flowsheet at the Champion stamp mill may be summarized as follows:

1. Mechanical classification of the stamp product.
2. Re-use of a portion of the dilute primary slime for splash in the mortar, thus avoiding additional dilution.
3. Absorption of all the dilute primary slime in the grinding circuit.
4. Roughing treatment of sand on tables with regrinding of all tailings.
5. Dressing water added for table treatment is discarded ahead of regrinding with less loss than if primary slime had been present.
6. Lower grinding costs by closed-circuit grinding and better mill adjustments.
7. Losses from overflow of slime thickeners almost entirely eliminated.
8. Less operating attention required.
9. Grade of concentrate considerably improved.
10. Mill recovery decidedly increased.

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Barite in Arkansas

George C. Branner

THE occurrence of heavy, dark-gray, fine-grained, loose surface rock in the southeast corner of Section 10, Township 3 South, Range 17 West, Hot Spring County, Ark., has been known to local residents since about 1900. In 1911, John Inglis took a piece of this rock to Joe W. Kimzey, of Magnet, Ark., who identified it as an impure barite. Mr. Kimzey later roughly traced the extent of the deposit from the distribution of the float rock and by digging shallow pits. In September, 1928, a specimen brought to the Arkansas Geological Survey by E. E. Bonewits, of Little Rock, Ark., was analyzed by the survey and found to contain: barium sulphate, 82.60 per cent; silica, 12.98; ferric oxide, 0.75; calcium oxide, 1.18; magnesium oxide, 0.12; sulphate other than barium, 0.71 per cent.

Attempts were made by the survey to interest persons in a detailed examination of the deposit, but it was not until the fall of 1930 that Moritz Norden, of Hot Springs, Ark., was informed of the deposit by the survey, and, with the assistance of Mr. Kimzey, examined the area. Mr. Norden caused two trenches to be dug across the outcrop of the deposit, and put down several shallow test pits. Following this, a test shaft was sunk to a depth of 28 ft. during November and December, 1930, and January, 1931. Except for the first 2½ ft., the shaft penetrated bedded impure barite, showing thereby that the deposit is probably one of some size.

One of the aforesaid trenches apparently cuts across about 85 ft. of barite, down the slope of a hill, and indicates a thickness, measured vertically to the bedding plane, of about 46 ft. at that point. Considerable drilling remains to be done before a final estimate can be made as to the quantity of material present.

The deposit is situated in a thickly timbered, hilly region. Elevations of the hills above the valleys are usually from 100 to 200 ft. The test shaft lies about 2½ miles northeast of Magnet, by county and country roads. Magnet is about 3 miles, by graveled state highway No. 6, from Butterfield station, on the Chicago, Rock Island & Pacific Railroad—a total of 5.5 miles, by road, from the property to rail transportation.

Structurally, the barite occurs along the north side of an east-west trending synclinal valley, typical of the region. Its length is approximately 2 miles, and it is closed at the east end. The bedded barite, which has an average slope of about 43 deg. at the shaft, conforms with the inclination of the adjacent strata in the syncline. About three-eighths of a mile west of the shaft, the dip increases to 61 deg., whereas at the east end of the syncline it decreases to 26 deg. The barite has been traced for a total of about three-quarters of a mile along the north flank of the syncline. The formation containing the barite is probably the upper portion of the Hot Springs sandstone of the Mississippian system.

In this formation, the barite-bearing material presents the appearance of a medium-gray sedimentary rock, stained by narrow, irregular, reddish bands. A study of many hand specimens, and also a microscopical study of the rock, lead to the belief that the barite has replaced some other mineral, possibly silica or lime. The specific gravity of the rock varies from 3.8 to 4. The average analysis of twelve samples of channeled ore taken from the deposit follows: barium sulphate, 87.26 per cent; silica, 9.02; ferric oxide, 0.92; aluminum oxide, 0.50; magnesium oxide, 0.27; and titanium oxide, 0.07 per cent.

Flotation tests made of the samples by the U. S. Bureau of Mines, at Rolla, Mo., indicate that the material can be satisfactorily concentrated. Fred D. DeVaney, associate metallurgist, states in a letter dated March 16, 1931: "We find that this material can be readily concentrated by a flotation process after grinding to 150 mesh. Flotation concentrates were made which had a tenor of 97.25 per cent barium sulphate, 1.76 per cent silica, and 0.11 per cent iron, with a recovery of a large percentage of the barite."

The fact that the barite deposit lies only about 2½ miles east of the well-known Magnet Cove area of intrusive, igneous rocks suggests that the barium salts have originated in the Cove and have replaced material in adjacent sedimentary beds. However, barium salts have not been reported to any extent in the minerals of the Magnet Cove area.

Mr. Bryan Parks, of the Arkansas Geological Survey, is preparing a report on this deposit, together with a geological map of the area, which will be ready for distribution at an early date.

Test shaft in barite deposit, Hot Spring County, Ark.

Water Treatment and Purification

John B. Huttl
Assistant Editor

FACTORS that govern the success of a power plant are (1) reliable service, (2) low steam and fuel consumption, and (3) conservation of plant machinery. Cheap power, supplemented by carefully selected production methods, means low production costs and increased earnings. One phase, which materially influences the life of power plant machinery, maintenance costs, and safety—and which in many instances is inadequately considered—is the correct treatment of raw water. Although it be available in abundance, the water, in many instances, must be first relieved of associated gases and salts—impurities acquired during its long travel through the atmosphere and the various strata of the earth's crust—before it can be used for the generation of steam or for cooling purposes.

Impurities contained in raw water, depending on the character of composition, may influence plant operation by the formation of incrustation and silt, due to concentration of salts in the water; and by corrosive action, caused by the gases and acids dissolved in the water. Both are harmful and dangerous and, therefore, undesirable. The effects of incrustation and silt are far-reaching, especially in boiler and turbine operations. Incrustation, particularly the siliceous variety, acts as an insulator on the boiler parts exposed to the fire, resulting in heat loss, low boiler efficiency, and increased fuel consumption. To counterbalance this thermal inefficiency, a higher temperature in the fire chamber is necessary. Operations are greatly endangered from a safety standpoint, because the metallic parts of the boiler, not being calculated permanently to stand excessive temperature, are subject to failures, costly shutdowns, or explosions. Uneven incrustation may cause considerable trouble. The same is true, but in the reverse form, with steam-turbine condensers. Failure to cool the entering exhaust steam rapidly because of incrusted condenser tubes causes decreased vacuum and machine inefficiency. This also applies to incrusted machine parts of Diesel and gas engines.

Corrosive action, although of no influence to actual boiler efficiency, is even more undesirable than incrustation for the reason that it decreases the life of the boiler and its auxiliaries, and endangers operation and life, because corroded parts or failures cannot be detected while the boiler is in operation. Particularly dangerous are capillary cracks along the rivet seams, detectable only by means of a microscope, which occur during construction of the boiler. Acidic and gaseous water will soon cause failures at these points, and explosions are then common.

With the present trend toward increased temperature and steam pressure, the prolongation of boiler life will not depend solely on the type of heat-resisting alloys used in boiler construction, but will depend also on improved water cleaners and purifiers. By placing the evaporators closer to the fire chamber, as is the practice with the modern high-pressure boiler, the demand on the materials is respectively greater. Incrustation on these parts will lead to their deterioration sooner than would be the case with the old type boiler, as practice has shown. Furthermore, in high-pressure steam boilers the steam may carry fine salt particles into the superheaters, pipe lines, and the machine itself, causing considerable damage. Experiments have proved that the salts and gases contained in the water corrode iron or steel more rapidly at higher temperatures.

The preparation of water can be divided into three distinct processes: mechanical and chemical purification, and distillation. The mechanical purification of water can again be separated into two stages: primary removal of coarse impurities by screen and settling tank installations, and a secondary treatment of water in filters, to extract the finer floating particles of silt and other impurities the water may contain. The filters generally consist of a shell provided with numerous perforated sheet-iron partitions, between which layers of coarse sawdust or gravel are placed, to offer the necessary resistance to the inflowing water and thus separate the contained impurities. Gravel fillings are preferable because the layers need not be disturbed or removed, as compared with the sawdust filling, during the cleaning period of the filter. Needless to say, the cleaning may be effected automatically, with built-in agitators or with compressed-air or high-pressure water connections. Impurities still contained in the water are then eliminated by chemical action, constantly in progress within the boiler proper, and are ultimately discharged by periodically blowing off the boiler. The simple mechanical method of purifying water is not always complete; depending on the nature of the water, a second treatment by chemical means or distillation is necessary to make it suitable for boiler or cooling operations.

Water hardness is caused by lime and magnesia salts contained in the water in varying quantities. The two types of hardness are best expressed as (1) the hardness due to carbonates—of lime and magnesia combined with carbonic acid—and (2) permanent hardness, based on carbonates of lime and magnesia combined with nitric, hydrochloric, sulphurous, and other acids. These can be removed by a process of precipitation by adding lime, soda, or caustic soda to the water, as is practiced in the well-known lime-soda and numerous other processes; or by a process of exchange, or regeneration, as is the method with the Permutit process.

The addition of lime removes the salts combined with double carbonic acid dissolved in the water, and also the free carbonic acid; whereas, the addition of soda separates all salts combined with nitric, hydrochloric, and sulphurous acids. All lime salts are precipitated as carbonate insoluble in water; magnesia salts, as hydroxide insoluble in water. Although the hardness from carbonates vanishes from the water without soluble alkaline salts taking its place, the water in turn absorbs much sodium chloride, sodium nitrate, and sodium sulphate, equivalent to the separated non-carbonates.

That the consumption of soda should be kept somewhat above the ascertained theoretical values is of importance, to prevent any chemical reactions which again may lead to the forming of lime and magnesia combined with sulphurous acid. To apply the lime-soda process successfully, a preheating of the water to be treated is recommended. The advantages thus obtained are the reduction of hardness to a minimum, ejection of a part of the injurious gases (carbonic acid, oxygen), and the precipitation, in less time, of impurities causing hardness. At higher water temperatures, the hardness formers are separated in a coarser form and, therefore, are easier filtered. Experiments have shown that the reaction at normal temperature (15 deg. C.) required from six to eight hours; at 50 deg. C., three hours; and at 70 deg. C., only one and a half hours.

The lime-soda process should be applied only to water containing considerable quantities of carbonic acid and carbonates. Disadvantages include the elaborateness of the plant, the need for constant and careful attendance, frequent sampling of raw and boiler water, and frequent washing of the boiler. The plants required for the lime-soda

process, which vary little in design, generally consist of the following main parts: water distributor; preheater; lime-saturator; storage vessel for soda solution; clarifier; and a quartz-sand filter. Provisions are made automatically to feed the soda solution in proportions corresponding to the water flow, and constantly to revolve the water in the clarifier to expedite the separation of the flocky impurities.

The caustic-soda process differs from the lime-soda process only in that caustic soda is used instead of lime, with the result that, during the chemical reactions, soda is generated along with the salts insoluble in water, which is again reconverted in the same manner as with the lime-soda method. This process is applied only to water containing excessive magnesia salts. Because of the higher price of caustic soda compared to that of lime, the operating expense is relatively higher. Space is lacking for discussing the numerous other methods, which resemble in general the lime-soda process, excepting the difference of chemicals used and in the arrangement of the flowsheets.

Of a different nature is the Permutit process for purifying and softening water. Here the principle rests upon the exchange of ingredients and not precipitation; in other words, aluminum silicates (zeolites) can exchange the contained alkali or other metals. The impurities responsible for forming hardness are therefore replaced by equivalent quantities of sodium and potassium when permitted to flow to the zeolite filters. A plant operating on this principle, except for the periodic regeneration of the zeolite by treatment with salt brine, needs no constant attention. Further advantages are constant and uniform operation, savings on floor space and chemicals, and the possibility of treating cold water with the same success as heated water. The Permutit process is best applied to water that is low in carbonates and carbonic acid.

When treating water of excessive hardness due to carbonates, sodium bicarbonate is formed from temporary hardness in the filter, which in turn is decomposed into soda and carbonic acid within the boiler. Carbonic acid and the presence of oxygen may cause corrosive action and consequent damage to the boiler. It is of utmost importance first to extract all the harmful gases carefully and prevent the formation of carbonic acid from the bicarbonate, which can be accomplished by a pretreatment with lime. As a result, however, the simplicity of the plant and low operating costs are largely sacrificed. The extraction of gases, especially of oxygen, can be accomplished with several methods, of which the simplest is to heat the water to 70 or 80 deg. C. This is followed by a less efficient method of passing the water over filters covered with steel wool and iron turnings, which are supposed to combine with the oxygen. These filters give good results for a short time, until oxidation and silt render them useless. The cleaning of the filters, in such an event, is of little avail. Of the other methods with which success has been achieved may be named the heating and boiling of water under vacuum, utilizing the exhaust steam of condenser pumps, boiler-feed pumps, and other steam-driven equipment.

The third group of water purifiers and softeners comprise evaporators and distilling apparatus. These, however, are seldom considered, because of the high installation costs. They are used at power plants where only a small amount of make-up water is required. The advantages obtained from thermal water purifiers include the impossibility of salts' entering the boiler and the avoidance of frequently washing out the boiler. The disadvantages are, mainly, the high costs for installation and maintenance of the necessary equipment.

Mention must also be made of the electrolytic process for preventing incrustation and corrosive action, of which little can be said today because it is still in an experimental stage. Numerous patented compounds and preventives have also been put on the market in recent years, with which those responsible for their introduction claimed that the objective can be accomplished by merely dissolving them in the raw water.

With the technical and chemical knowledge available today, any water can be made suitable for boiler operations and cooling purposes, depending entirely on the nature of the water and operating conditions, and selecting the method most practicable and economical. With the demand for higher steam pressures and temperatures, the future will undoubtedly bring further improvements and changes successfully to meet the new conditions.

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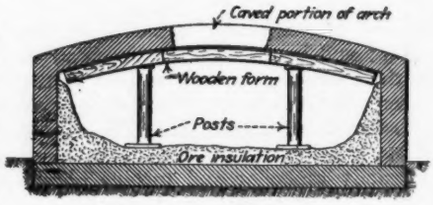
Reverberatory Furnace Repair

AT THE reverberatory department of Compagnie Du Boleo, Santa Rosalia, Baja California, a small section of the arch on one of the 18x72 ft. furnaces suddenly caved in, writes Victor Mussio, smelter superintendent. To avoid a long shutdown, the loss of smelting capacity, and to prevent cooling of the furnace, a method had to be devised for repairing the damage in shortest possible time. The problem was solved in the following manner: After tapping slag and matte the burners were shut off, and the walls and bottom near the break cooled gradually by careful spraying with water. A wooden form supported on four posts was adjusted to the arch after introduction of cold ore, serving as an insulator, into the furnace, as shown in the accompanying sketch. Cooling air for the repair crew was furnished by a small, portable blower.



The gap was then carefully closed with standard arch bricks, and the furnace was again in operation after only a few hours' shutdown.

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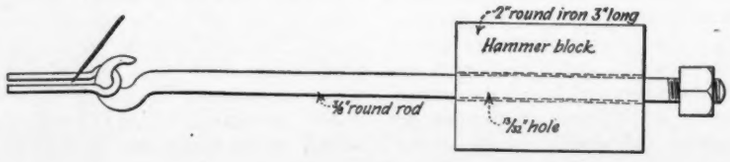
Cotter-Pin Extractor

REMOVAL of cotter pins from crankcase ports or doors of Diesel engines is a difficult and tedious task, on account of the restricted dimensions and other objectionable features often encountered. To prevent tools from falling into the crankcase filled with oil, and to avoid injuries to the hands—common occurrences when removing cotter pins without special tools—Thomas C. Hulton, master mechanic, Cia. Minera Chambas, Abras Grandes, Cuba, designed the simple and inexpensive extractor illustrated in the accompanying sketch. It can be made in sizes to fit any pin and all conditions, and consists of a $\frac{3}{8}$-in. rod with a specially designed hook at one end, and with a movable hammer block made of 2-in. round iron, and a lock nut, at the other end. The hook is placed into the opening of the pin head, and the block slid back and forth on the rod, the hammer-like blows slowly removing the pin from the bolt or nut.



Fire-Refining and Casting of Electrolytic Copper

L. C. Fopeano

METALLURGICALLY, the fire-refining of wirebar copper is comparatively simple, yet the quality of the castings demanded by the rolling mills requires careful control throughout the process—a control that often is too dependent on the personal judgment of the operator unaided by scientific data or instruments. The age and the importance of the industry considered, the data available to assist in the investigation of operating difficulties are surprisingly meager. In this article an attempt is made to suggest instruments useful in an investigation and to outline some data on the practical operation of refining furnaces collected during numerous investigations by myself and others.

The important subject of furnace design is beyond the scope of this article; it will be assumed that the furnace design and the class of material treated—electrolytic copper or its equivalent—have given satisfactory results in the past and that a periodically recurring trouble in refining and casting is the main consideration. The impurities in electrolytic copper are usually within such narrow limits that, though poor cathodes often furnish a convenient excuse for the furnace refiner, seldom can they be proved to be the source of trouble.

Improper fuel control and temperature are the underlying causes of most refinery troubles. Ladles, molds, mold temperatures, mold wash, and such, are all important, but can be controlled satisfactorily if the bath itself has been properly handled. The various periods of the process will be discussed.

Charging

Little can be said of this period other than the necessity for speed to conserve the heat of the furnace and prevent unnecessary chilling of the brickwork. The use of hydraulic or air-lift doors effects a considerable saving in fuel, brickwork, and time in operation. Usually, a covering of light material is charged on the bottom to protect it from the impact of heavy materials. Care is taken not to block the "verb" and thus prevent free exit of furnace gases.

Some refineries have a practice of charging through the bridge door as soon as that end of the furnace is dry, which may be twenty or thirty minutes before the furnace has drained at the taphole. This practice saves time in the cycle and prevents overheating the last few tons in the furnace.

Melting

To insure efficient combustion, the amount of fuel and combustion air should be metered and the proper combinations of air, fuel, and draft determined by gas analysis. Several types of recording and integrating flowmeters on the market may be used for measuring air and gas. The Foxboro Orifice meter may be mentioned as giving satisfactory results. Accurate measurement of rate of flow of small volumes of fuel oil is more difficult; one refinery uses an Esterline-Angus time recorder in connection with the regular Worthington plunger type meter. The passage of every ten gallons actuates an electrical contact on the meter dial and is recorded by a stroke on a moving chart. Distance between strokes indicates the rate of flow.

The vertical and lateral positions of the burners and air nozzles should be recorded with reference to a fixed point on the furnace so that the effect of variation in the direction of the flame and secondary air may be noted. Needless to say, the position of the burners has a marked effect on the speed of melting, life of roof, and even quality of product.

A convenient method of taking gas samples from the furnace is through a water-cooled sampling tube inserted through the roof in back of the "verb" and projecting about 18 in. inside the roof. A piece of 3-in. pipe 43 in. long forms the jacket in which are welded a $\frac{1}{8}$-in. sampling tube, a $\frac{1}{2}$-in. inlet water tube extending almost to the bottom of the jacket, and a short outlet tube. The whole apparatus is suspended by a bail, flexible cable, and counterweight so that it may be withdrawn easily after taking the sample. If the brickwork is tight, samples may be taken through a silica tube in the uptake. Obviously, such samples are worthless when the skimming door is open.

The Orsat apparatus is sufficiently accurate for these analyses. Although ideal combustion is indicated by absence of both carbon monoxide and oxygen, it is advisable to carry 2 to 3 per cent free oxygen to insure complete combustion and prevent gassing the copper. The gases absorbed during this period may not be expelled by subsequent treatment.

The question of draft is important. A rough calculation may be made of the draft necessary to carry off the expanded air and fuel introduced in the furnace. A recording draft gage should be installed in the uptake about 4 ft. above the arch of the skimming door. Usually, 0.4 to 0.6 in. draft is carried during this period.

No set rules can be given that will apply to every furnace. Tests must be made and a careful record kept of the fuel, air, draft, position of burners, flue gas analysis, and their effects on time of melting and blowing and quality of product.

Skimming and Blowing

In some refineries several skimmings are made, starting before the charge is flat; in others, the furnace is kept closed and at full heat until boiling has stopped, whereupon the bath is skimmed clean at one operation. The former method hastens the melting of the charge by removing the heat-insulating layer of slag and allowing the heat to penetrate the lower part of the charge more quickly. Considerable prejudice exists among some refiners against opening the furnace or putting in air pipes until boiling has practically stopped. In a 300-ton furnace this period usually lasts about an hour. Full fire is maintained and the bath reaches a temperature of around 2,040 deg. F. by the end of the period. The brickwork holds sufficient heat to allow a small fuel consumption during blowing. This is of considerable advantage in manipulating the pipes, as they do not soften so readily and may be held deeper in the bath and better agitation effected.

Vertical sampling has shown a marked

segregation of cuprous oxide in the bath; the top two inches contained 20 per cent more cuprous oxide than the metal immediately underneath. This demonstrates the necessity of taking the final sample buttons from various parts of the furnace and from areas that are being well agitated.

Some refineries make a microscopic estimation of the cuprous oxide content to control the length of blowing period. An oxygen content of 0.9 per cent is considered ample to insure the oxidation of impurities. With charges of electrolytic copper, only 0.6 per cent may be sufficient. However, the mere presence of this amount of oxygen is not absolute proof that the impurities have been scorified. Temperature plays an important rôle during this period. It should reach a maximum—around 2,080 deg. F.—in the early part of blowing, then fall to about 2,000 deg. during the latter part.

An analyst experienced in the use of the microscope can judge by the appearance of the excess cuprous oxide if the impurities have been eliminated. Overheating, or the incomplete scorification of arsenic, antimony, and other impurities, causes nodular deposits of cuprous oxide rather than long dendrites. The appearance of the surface and the fracture of the sample button is still the refiner's criterion. Normal practice is to blow the charge until the button fracture shows no silky structure along the bottom edge, and definite brick-red cubical structure is evident. The shrinkage hole has a dull deep-red color.

In refining charges high in impurities, particularly lead, equal parts of crushed limerock and silica are sometimes thrown on the bath, after partial oxidation; and the charge is thoroughly mixed by blowing to permit the bath to come in contact with the lime-silica slag.

The maximum density of the bath exists just after skimming and steadily decreases during the blowing and poling periods, owing to gas absorption. Elimination of sulphur takes place largely during the first hour of blowing; reabsorption occurs during the latter part of poling. Great care must be taken in the manipulation of air, fuel, and draft, to minimize absorption of combustion gases. The flame should be short and directed well above the surface of the bath. Three or four tenths of an inch draft is customary during blowing.

Poling

Rapid changes of temperature are to be avoided during poling and casting. A large volume of fuel may cause abnormal gas absorption by local overheating, with consequent strange effects on color and set and abnormal shrinkage in the molds, causing cracks. The furnace atmosphere should be as nearly neutral as possible with a minimum of secondary air. High-pressure air that gives a short white flame close to the firebox is preferable. The draft should be just sufficient to prevent the gases from poling backing up in the furnace and causing incomplete combustion of the fuel. Two-tenths of an inch is usually sufficient. The temperature should be followed closely, with frequent pyrometer readings, in order to have the proper starting temperature at the finish of poling—around 2,050 deg.

A method favored by some refiners as a panacea for porosity troubles is to burn a few poles in the bath after oxidation is complete and before covering the bath with coke. It is doubtful if this method is necessary in refining electrolytic copper with small sulphur content and using low-sulphur fuel and proper conditions of combustion.

Casting

Two types of pyrometers suitable for temperature readings in molten copper will be mentioned. For readings inside the furnace a base-metal couple with an iron protecting tube such as the Brown MA couple with high resistance pyrometer No. 120 gives satisfactory results. The iron tube—ordinary ½- or ¾-in. iron pipe welded at one end—is safe for six or eight readings. It should be heated to 1,000 deg. before immersion in the bath to reduce the time it is subject to the corrosive action of the copper. Spare couples and tubes are quite inexpensive. About a minute in the bath is required for the instrument to reach a constant temperature. During blowing, temperatures may be taken conveniently through the skimming door. Before opening the furnace it is advisable to take the temperature through the taphole, opened above the metal line. There may be a difference of fifty degrees or more between the skimming door and bridge, particularly if large, green poles are used.

"Tycos" molten metal pyrometer No. 4061 is better adapted for rapid readings in the launder or ladle. The instrument is provided with bare thermocouple ends, which are plunged beneath the clean surface of the metal. The ends are not joined, the surface of the metal completing the circuit, and for this reason it must be free from slag or oxide, or erratic results will be obtained. This condition may be obviated by wrapping a sleeve of asbestos tape around each wire, leaving only two inches at the end bare. The points are completely immersed in the running metal with a quick jabbing motion. The insulating sleeves prevent erratic thermal effects from the surface. Both these instruments should be internally compensating for cold-junction temperature, to eliminate the variable of atmospheric temperature around the furnaces and permit easier calibration.

Great care should be taken in reading and in keeping the instrument calibrated; a single inaccurate reading may break down the confidence in the instrument among the practical operators who often are not particularly sympathetic toward pyrometer control. The apparent discrepancies between the temperature as shown by the pyrometer and by the behavior of the metal in casting may be explained by changes in characteristics of the copper other than those caused by temperature. Both oxygen content and gas absorption have an effect on the tendency of modern copper to stick and form skulls on the ladle bridge and lips.

After it is seen, while casting warmers, that the ladle is pouring satisfactorily, reject bars or warmers may be thrown in the bath to lower it to the correct temperature for casting. The fuel should be regulated to maintain an even temperature in the bath throughout the charge. To increase the production of a furnace some refiners burn more fuel during casting and continually charge in reject bars to lower the heat. The difficulty of handling the charge makes the economy of this practice questionable. The fuel should be burned with a clear short flame, preferably with high-pressure air. Draft may be carried as low as 0.1 in. with a small fuel consumption.

A prolonged study of the effect of temperature on casting defects and casting efficiency showed that cracks, side splashes, porous spots, pits, and imbedded mold wash increased as the casting temperature increased. The most favorable temperatures for various shapes follow:

	Deg. F.
135-pound wirebar	2,020
175 to 200-pound wirebar	2,040
225-pound wirebar	2,000
250-pound wirebar	2,000
14x17-in. flat cakes	2,040

These temperatures were taken in the launder; the bars were cast from a 3-ton ladle.

The ladle should be sufficiently large and deep that the eddies set up by the stream falling from the ladle do not affect the volumes pouring from the lips as the level of metal varies in the ladle. A ladle of less than 2 tons' capacity is likely to pour unevenly unless the stream hits well away from the bridge and the tapper is very careful to maintain a constant level of metal. A flat, wide lip is considered the best form for pouring wirebars. A width of 3 to 3½ in. gives good results for standard 225-lb. bars.

Hollow aluminum cores in an adjustable frame may be used conveniently to form the lips. The cores are set properly in the ladle, leveled, and the cement-sand mixture is poured around them to form the entire front of the ladle. A light charcoal fire on a piece of sheet iron is placed on top for a few minutes until the cement has set sufficiently for the cores to be withdrawn. This leaves the bottom of all lips level and of the same width. Very little "doctoring" is necessary at the start of casting.

A convenient method of measuring mold temperature is to insert a thermometer in a hole 2 in. deep drilled in

the middle bridge in the center of the mold. The Brown Instrument Company manufactures a metal-clad thermometer in which the space between the bulb and the metal protecting tube is filled with mercury. The thermometer fits snugly in the mold and reaches a constant temperature in about two minutes. One refinery carries a mold temperature of 200 deg. F. and with a "Murphy Pistol" applies a mold wash of eight parts of water to one part of a mixture of two parts of calcined bone black and three parts of bone ash. Another refinery carries a temperature of 250 to 300 deg. and applies a mold wash of six parts water to one part straight bone ash with a Best 2N oil burner. The lowest mold temperature at which the wash will dry evenly seems to be most satisfactory.

A wide diversity of opinion exists on mold cooling. Some refiners apply the water on both top and bottom of the mold as soon as the bars have set but do not apply any water in the pockets after the mold has dumped. This is to prevent the incrustation, in the pockets, of salts from the water. Others take an opposite view and apply most of the cooling water to wash out the pockets after dumping. It is quite generally agreed that with the straight-line or Clark type of casting wheel the pouring end of the mold should be kept the cooler to prevent unequal solidification of the two ends and possible cracking of the bar.

Various materials, such as barite, smut, carbon black, silica, natural phosphate rock, chemically precipitated phosphate, and others, have been tried as mold wash, but none have gained the universal favor of bone ash. Much difficulty is encountered at times from bone ash, and considerable experimentation has attended its use, but no entirely satisfactory tests have been devised to determine what constitutes a good quality. To be a satisfactory mold wash, a substance must not react with molten copper. It must adhere to the mold; it must present a smooth surface over which the copper flows freely; and it must not contain volatile constituents that may cause spongy spots in the castings. Bone ash contains 75 per cent tricalcium phosphate, the only ingredient that meets all these requirements. The other constituents—sulphates, chlorides, carbonates and oxides, of calcium, magnesium, sodium and potassium, and silica—occur in varying amounts according to the source of the bones and are contaminants for use as mold wash.

About 1 per cent of bone ash is soluble in water and consists principally of sodium carbonate, sulphate, and hydroxide. These three substances were added to normal bone-ash mix to observe the effect of higher concentration on the castings. When the sodium sulphate was raised to 1.2 per cent there was no effect. Excessive pitting resulted, however, when the sodium carbonate content was raised to 1 per cent, and when the sodium hydroxide was raised to 1.2 per cent.

These results suggested that neutralization with sulphuric acid might be feasible. Such was the case. Normal mix containing 0.3 per cent sodium hydroxide gave good castings; when more was added to raise the total alkalinity to 1.0 per cent heavy pitting resulted. Then, dilute sulphuric acid was added to bring the alkalinity back to 0.2 per cent, and pitting stopped.

Usually, the calcium carbonate content is about 2 per cent. No effect was apparent when the concentration was raised to 4 per cent. Normal bone ash contains 0.2 per cent or less unburned carbon. Lamp black was added to raise the carbon content to 1.0 per cent, and no effect could be observed. Calcium hydroxide was added to double the amount usually present, with no apparent effect. Pulverized silica had a very pronounced effect; 3 per cent will cause excessive pitting. Addition of hydrated lime counteracted the effect of the silica.

Magnesium salts adhere to the mold very poorly.

The best bone ash is apparently a slow settling, well-dispersed slurry that does not coagulate. One refinery has set the minimum allowable settling rate of a one-to-four mix (by weight) as one inch in five minutes. Wet screening should show at least 93 per cent through 300 mesh. Coarse material does not adhere well. Often a practice is made of mixing bone ash from several barrels for current consumption to minimize the effect of a chance barrel of poor material. This also provides uniform bone ash for several charges for comparison.

Oil or grease in the molds will cause spongy spots, so every safeguard to prevent this should be installed permanently. Sufficient coolers, receivers, filters, or traps should be placed in the air lines to the bone-ash mixing tanks, atomizers, and pipes for blowing out the molds to prevent, beyond all doubt, any oily condensate reaching the molds. Careless lubrication or a leaking gasket in the compressors may be a mysterious and costly source of trouble.

The water for mold wash should be oil- and rust-free condensate, stored in closed tanks. Care should be taken that bosh water with a film of oil or grease does not splash in the molds. Cranes should not park over the casting wheel, and, while changing molds, light sheet-iron covers may prevent grease from the crane block falling into the molds. Mold-dressers' tools should be free from excess oil and grease. Suction hoods over the ladles or shields between the ladle and the molds prevent charcoal sparks from falling into the molds. Low-pressure air jets may be used to blow out the pockets just before the casting is started.

These refinements may seem trivial and bothersome, but a few bars a charge saved from rejection amply repays the cost of the operator's assurance that these minor possible sources of trouble have been eliminated and makes simpler the investigation of major difficulties. Usually an inspector's report shows a preponderance of rejections from trivial causes.

The operator who in periods of good production definitely determines the proper operating conditions with scientific instruments, and eliminates any doubtful practice, has gone far in locating the source of difficulty in periods of low efficiency—periods which occur in spite of the most careful supervision.

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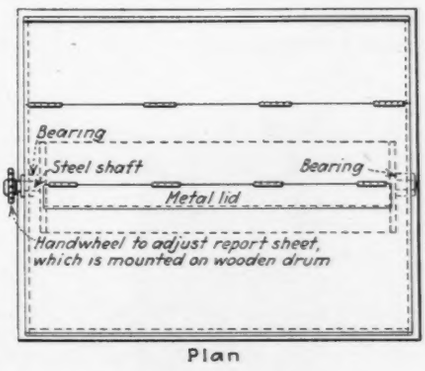
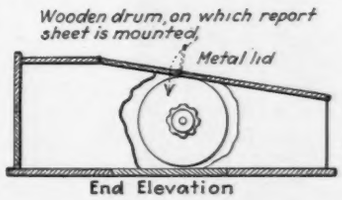
Desk With Built-in Report-Sheet Holder

A DIFFICULT task at the power house, mill, or smelter is to keep report sheets neat and clean. The operator in charge, performing divers duties during his shift, cannot avoid having oily and unclean hands. To overcome this inconvenience, the assistant power plant engineer at the New Cornelia mines of Calumet & Arizona, at Ajo, Ariz., has designed the desk shown in the accompanying sketch. Instead of the report sheet being on the desk, exposed to the operator, as is the usual practice, it is mounted on a built-in revolving drum operated by a small handwheel. The desk lid is provided with a rectangular slot, somewhat longer than the report sheet, through which the operator can make his entry after he has first lifted the metal lid or covering.



Plan



End Elevation

SIXTY YEARS AGO

Copper Mining in Michigan Dates From 1844—No Smelting in the District in the Early Days

☞IF READERS WILL NOT BE TOO METICULOUS about the appropriateness of the heading "Sixty Years Ago," we shall supplement the description of the Combination Bar, in Goldfield, Nev., published Sept. 8, 1930, by a little material concerning the Lake Superior copper region, which was recently found buried in an old volume of *Harper's New Monthly Magazine,* for March and April, 1853. A gentleman by the name of Robert E. Clarke set out from Chicago in July, 1852, for the copper country, and in two detailed articles described his experiences for the benefit of *Harper's* readers. Some of the pictures he brought back with him are reproduced herewith, so that the people around Houghton and Calumet can see what was going on then, and pine, if they wish to, for the good old days.

Mining in the veins

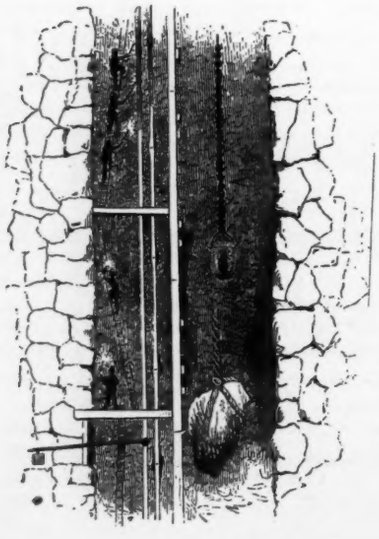
Mining operations were first commenced in the Lake Superior copper country in 1844, according to Mr. Clarke, and by the time he visited the district, 2,500 tons of copper a year was being produced. This was a whole lot, as the entire copper production of the world was then only about 28,000 tons a year. It was worth about 20c. a pound.

Mr. Clarke went underground at the Cliff mine. "Before entering . . . it is necessary on account of the water . . . to shift, that is, to change one's habit. He will assume instead the usual miner's garb . . . consisting of rough, strong overpants, a large woolen shirt, and hard round hat or cap of woolen material. Seeking thence the Raising-room, where the metal and veinstone first sees the upper air, the visitor is handed a lighted candle, with a lump of clay adhering to it; this, for the greater convenience of carrying, of sticking against the rock if desired, or on top of the hat just alluded to, in order to leave both arms free. All things being now ready, your guide raises the trap-door, and you descend by ladders firmly attached by iron staples and bolts to the rocks," as shown in the accompanying sketch. This also shows one of the kibbles, in which the ore was hoisted, counterweighted with a huge rock. The horse-operated "whin," for raising the kibble to the surface, is shown in another drawing.

The lowest level, or fifth, was 420 ft. from the surface, and from there one could look down 70 ft. further where the sinking of the shaft was proceeding. Two other shafts were also in use at the Cliff mine at that time.

"Progress in excavation is effected by the drill and hammer, followed by blasting. Commencing with a short drill—the common cold chisel—longer ones are used as the hole is sunk deeper. In this way the rock is often bored to a depth of 6 ft. One man holds the drill, which he keeps revolving; while two others, with alternate strokes of 7-lb. hammers, gradually drive it to the desired depth. Sometimes, what is termed a hall, that is to say, a cavity large enough to hold a keg of powder, is formed behind a great mass of rock which it is desired to move." The powder was fired with a fuse, "the proper length of fuse, united to reasonable caution, generally enabling him to place himself out of danger before the explosion."

"Doubtless there is nothing which the visitor will see in the copper region, which will produce in him such lively emotions of wonder and admiration, leading the mind directly to the mighty,



At the left: Descent of a shaft . .

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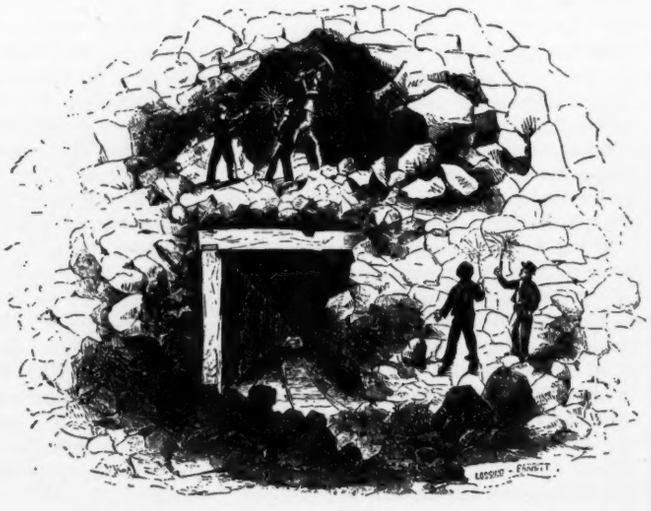
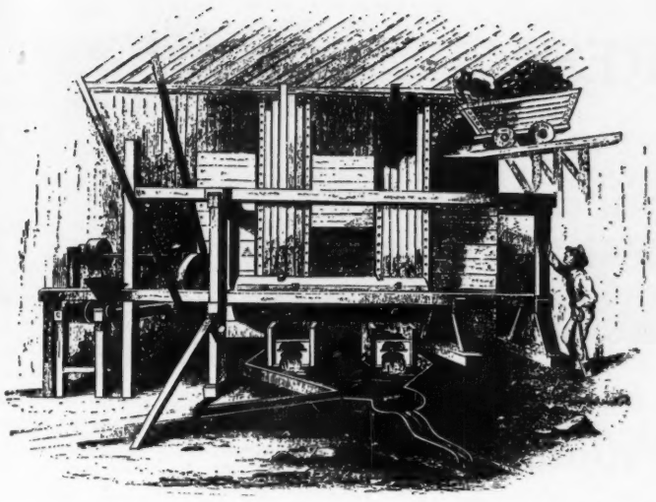
At right: interior of a copper mine





At the left is a view of the early stamps

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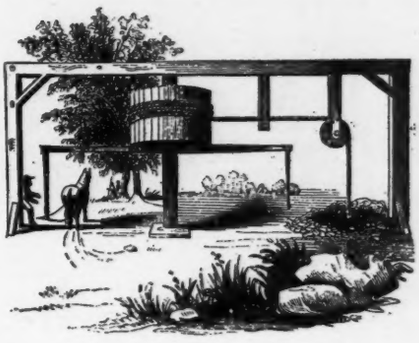
At right —a "whin"



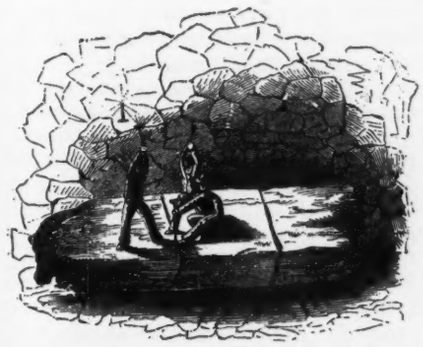
troit to Lake Superior ports are usually $1 the barrel bulk—increased to $1.50 by the time of reaching the mines.

"That all higher social and humanizing influences are not wanting . . . the stranger will see gratifying evidence here in the church and schoolhouse. The Methodist denomination has a regularly officiating clergyman, and a school is supported by private patronage at which some 36 pupils receive daily instruction. No spirituous liquors are allowed to be sold on the locations, and stringent regulations exist for the control of such miners as show a disposition to disorderly behavior or neglect of business." E. H. R.

yet hidden and mysterious forces of nature, as the Mass Copper . . . He beholds before him the palpable result of secret and marvelous agency." And yet, these big masses of pure copper meant a lot of work for the miners who broke them up solely by chisel and hammer as shown in the sketch reproduced herewith. "A mass of 18 in. in thickness and 4 ft. across, will in this way require eight days to divide it."

After the ore was raised to the surface, it was placed in a pit kiln, holding about 60 tons, sunk in the ground, on top of 3 ft. of firewood, beneath which was a cast-iron grate. After roasting in this way, it could easily be broken up into small pieces not exceeding 2 lb. in weight, and was then ready for the stamps, two batteries of which are shown in the picture. The stamps weighed 400 to 500 lb. each, and the two batteries were run by an 8-hp. engine. The crushed ore was manipulated in pits, floors, jiggers, and buddles, until all of the copper was separated from the rock, the copper then being sent to Detroit, Cleveland, or Pittsburgh for smelting. The process of separating the copper from the rock was introduced by Captain Jennings, who brought it from the Cornish tin mines.

The Cliff mine at that time employed about 260 men; the North American about 75. Surface men got $26 a month. "Stoping is paid for by the cubic fathom, in obtaining which the product of the length and breadth, the thickness being omitted, is divided by 36. The rate varies from $18 to $35. Drifting—the usual size of the drift being 6 ft. by 4—is paid for at the rate of $5 a foot horizontal. For sinking a shaft, whose usual size is 10 ft. by 14, the compensation is from $10 to $15 the foot vertical. For cutting copper by hammer and chisel, the workmen receive from $1.34 to $1.50 per diem. In all cases, the miner finds his own candles, his own fuse, and powder. Freights from De-



Separating the copper blocks

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Grinding Drill Shanks

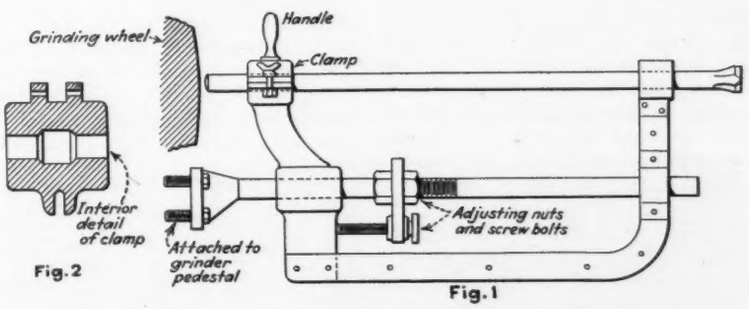


Fig. 2 Fig. 1

UNEVEN and untrue shank ends of machine drills may influence materially the life of drill parts and drilling operations. To prolong the life of drill pistons and chucks and insure smooth drilling, truly squared-off shank ends are essential. At most properties this is accomplished by grinding the ends manually in a stationary emery grinder —a most unsatisfactory method, from either an operating or a safety standpoint. When facilities are not available with which to hold and support the drill properly while it is being ground, a poor and untrue shank end will result, despite the length of time devoted to the grinding. To expedite and simplify this operation, the jig illustrated in the accompanying sketch, with which the shank ends can be trued mechanically, was developed and adopted at the drill-sharpening shop of the Moctezuma Copper Company, Pilares, Sonora, Mexico. The device consists of: (1) a sturdy flat-iron frame, with two bearings; (2) a hinged clamp, an interior view of which is shown in Fig. 2; and (3) a V-grooved end support, mounted on and revolving around the shaft or bar, equipped with a simple adjusting mechanism and bolted onto the grinder pedestal. Operation of the device is simple: The drill, resting between the clamp and end support, after being secured tightly to the clamp by tightening the winged nut, is adjusted carefully according to the calculated feed, and, with the handle attached to the clamp, is then passed slowly across the face of the rotating emery wheel.

INDUSTRIAL PROGRESS

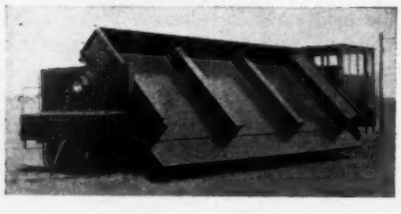
Power-Car Unit Promises Economies Around Quarry, Pit, Plant

R. H. Dalgleish, Jr.
Transportation Division
Westinghouse Electric & Manufacturing Company

A DEVELOPMENT, unique in conception and design, has recently been perfected by the *Differential Steel Car Company,* Findlay, Ohio. Essentially, it consists of a locomotive chassis on which is mounted a dump body—a self-contained unit carrying its own power plant, intended for service in open-pit mining and quarry work and around metallurgical plants. Steam equipment is usually uneconomical in many operations of this type, because of high maintenance and operating costs. Electric power may not be available or is costly, or the expense of an electric distribution system is not warranted.

The need has long been realized for an economical self-propelled vehicle for temporary work, such as stripping overburden from an orebody and other similar operations, where to set poles and string trolley wire or to provide substation facilities would not be desirable. Around smelters and milling plants such a vehicle can be used for switching loaded and empty cars and for the disposal of waste. In operations of this kind the unit to be described is especially suitable, because the gasoline engine is well understood by the average mechanic, and the simplicity of the electrical equipment combined with it is such that particularly skilled help is not required. In operations of this kind, where service required is intermittent, the economy of this vehicle is apparent. Fuel consumption stops immediately the switch is cut off.

The gas-electric locomotive illustrated herewith carries a 24-yd. level-load dump body. A sturdy truck-and-frame construction has all the features of a locomotive, and the dump body allows a load to be hauled on the locomotive as well as on trailer cars. The locomotive alone is available for stockpiling, and a variable tractive effort may be obtained by altering the load on the body.



The unit weighs 45 tons light and 80 tons loaded. Air-brake equipment is a Westinghouse combination "straight and automatic," with a Gardner-Denver 60-ft. compressor belted from each engine, giving an air capacity of 120 cu.ft. per minute. Truck center distance is 29 ft.; wheel center, 5 ft. 6 in.

In this device the power plant, mounted between the center sills, is protected from falling material. The radiators, of the sectional type, are mounted along the side sills. Being blown by centrifugal fans through holes in the side sills, they are thus protected from damage.

This particular unit, a combination power plant mounted on a sling between the sills, consists of two Buda JH-6 gasoline engines, each rated at 155 hp., at 1,200 r.p.m.; two 180-D-5 Westinghouse generators; four Westinghouse 908-RH motors; and the necessary control apparatus for convenient and efficient operation of the locomotive.

The electrical equipment comprises apparatus necessary for the transmission of power from internal-combustion engines—the source of power in this type of locomotive—to the driving wheels. It also provides means to control efficiently the speed, tractive effort, and acceleration of the locomotive.

The Differential Steel Car Company has pioneered in the design of many types of self-propelled vehicles, and has contributed greatly to the art of handling materials. The unit now announced is one more step in the march of progress in the production of efficient equipment for economical haulage. Advanced features in design, resulting from the long experience of the Westinghouse Company in the manufacture of successful traction apparatus, have been incorporated throughout, resulting in a unit of sturdy construction and reliable operation, in which minimum weight, combined with simplicity and accessibility, has been achieved.

A simple scheme of control of this locomotive provides maximum tractive effort during the first part of the acceleration at low speed, as well as higher locomotive speed when high tractive effort is no longer required. All starting, stopping, reversing, accelerating, and dumping operations are controlled from the operator's station.

The controller (Type XD-50) is arranged with two handles, one for reversing the direction of motion of the locomotive and for connecting the motors in series or parallel, the other for controlling the speed of the engine and, therefore, of the locomotive. Owing to the mechanical interlocking provided between the handles of the controller, the equipment is safeguarded against dangerous and abusive operation. The removal of a key serves as an effective lock against unauthorized operation.

A speed handle controls the speed of the engines and operates a drum that makes the electrical connections essential for the acceleration of the locomotive. Movement of the handle to the first notch will connect the motors in series or in parallel and to the generators, depending on the position of the reverse handle. Further movement of the speed handle increases the locomotive speed until full engine speed is reached. Additional movement is provided to raise the field current of the

generators for more efficient engine loading at the higher locomotive speeds.

The generators, arranged to charge the battery during engine idling, also serve as series motors for starting the engines, using the battery as the source of power. The double power-plant unit allows for flexibility and economy, by running with one engine while dumping or switching light loads. It also permits standardization of equipment for small and large cars.

Maximum tractive effort is 36,000 lb., with a free running speed of 19 miles per hour, light. Acceleration is exceptionally rapid. The unit has several advantages over mechanical-drive equipment. It is more flexible in operation, either or both power plants being available for use as desired. It is easily handled by the operator, no physical effort being needed for work such as shifting gears. It is more economical to operate, because one engine may be used, and maintenance is considerably reduced on electric drive. The equipment performs better, of course, under extreme conditions of load and grade.

■

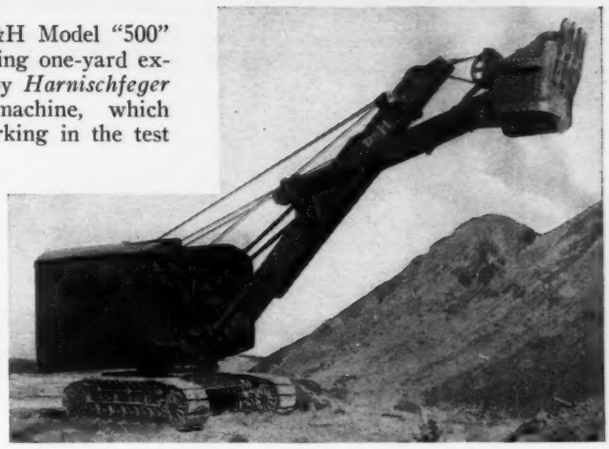
New Development Indicates Opportunity in Crushed-Stone Field

A JAW CRUSHER of novel design for the quantity production of fine stone has been developed by *Allis*-Chalmers, known as the No. 248 fine crusher. Within limits of capacity and reduction, it can produce, in a single operation, a finished product that ordinarily could be obtained only by using a primary crusher followed by a finishing machine such as crushing rolls. This makes it especially suitable for small plants where it is desirable to produce fine stone in one operation.

This crusher is a departure from the design of other types of standard Allis-Chalmers jaw crushers, as it has but one toggle plate and no pitman, the swing jaw being mounted on the eccentric shaft, from which it receives its reciprocating motion. Simplicity of design, with few working parts, greatly increases the accessibility to all elements of the machine and freedom from expensive delays the result of breakdowns. Bearing troubles, so prevalent with crushers subjected to fine reduction work, have been avoided by the use of roller bearings in the eccentric shaft and frame. The distance between the jaws regulating the size of the finished product is governed by a hand wheel. This adjustment is quickly made by turning the hand wheel and without stopping the machine, changing parts, or using tools.

New One-Yard Excavator Exhibits Engineering Improvements

KNOWN at the P&H Model "500" a new, full-revolving one-yard excavator is announced by *Harnischfeger Corporation*. This machine, which "spent the winter" working in the test field, follows the general P&H design with many added refinements. Main frames are unit alloy steel castings; wearing parts of alloy heat-treated steels; drums, in tandem, operate through the P&H power-clutch control. A minimum number of gear reductions makes this new machine extremely simple. Sturdy gasoline, Diesel, or electric motors provide ample power, whether the machine is used as shovel, dragline, crane, clamshell, hoe, or skimmer.



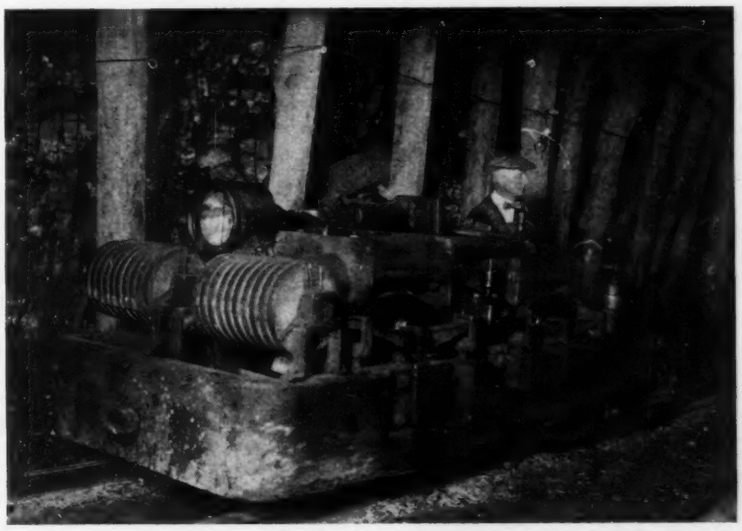
New P. & H. Model 500

Corduroy (crawler) frames, cast from alloy steel, are bolted directly to the car body. The crawlers employ the P&H double-sprocket drive directly engaging the link pins. Twelve pairs of alloy heat-treated rollers distribute the weight of the machine through the corduroy shoes to the ground.

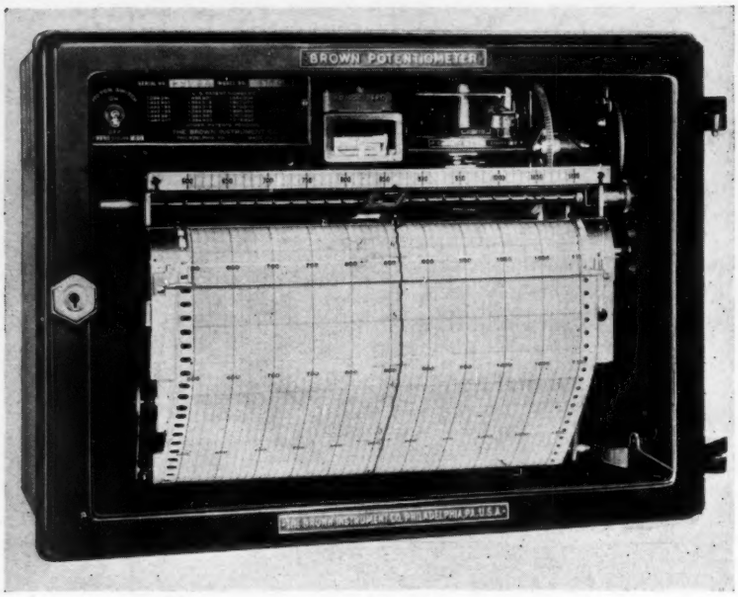
The patented P&H chain crowd with fast return is used. Shovel boom is of sturdy, box-section construction. The dipper has manganese-steel front and is equipped with renewable reversible teeth.

Dragline and crane booms are of trussed structural design. Equipped for dragline operation, the new model handles the one-yard bucket on a 40-ft. boom. As a crane with the same length boom, it is rated at 31,700 lb. at 12-ft. radius, which is 75 per cent of the tipping load.

Veteran Electric Loco Is Retired



One of the earliest electric mine locomotives to be placed in service, in Ohio in 1892, and which operated until recently, was named the "Charlie Smith," after the first driver. It was a General Electric unit of 60 hp.; 9 tons; 2½-ft. gage; speed of 8 miles per hour with load. It has now been placed on exhibit



New Potentiometer Pyrometer

TO RECORD and control temperature automatically, with extreme precision, is the prime object of an instrument, of sufficiently sturdy construction to withstand severe service conditions, recently introduced by the *Brown Instrument Company,* Philadelphia, Pa. It possesses many features new to potentiometer pyrometers, including a positive driving mechanism controlled by the galvanometer and exerting minimum force on the galvanometer pointer, and a long 40-in. slide wire, inclosed in glass, which can be immersed in oil if protection from corrosive gases and vapors is necessary. Another improvement is an automatic compensator to correct pen position for expansion and contraction of the chart paper with change in atmospheric humidity. Automatic temperature control is obtained through mercury switches, which can handle up to 25 amp. directly, without the use of relays. The case has been designed so that the instrument can be mounted as desired. More than 50 additional features characterize the design of this new instrument.

■ ■

Sealed Lubrication Is Feature of Motor Development

A NEW double-sealed ball bearing, as the standard anti-friction bearing on all Red Band motors, is announced by the *Howell Electric Motors Company.* The balls and ball raceway of this bearing are packed in high quality congealed oil and completely sealed in a dust-proof room at the point of manufacture. This avoids possibility of dust, dirt, or other injurious abrasives entering the interior of the bearing in the process of manufacture. The seal—which consists of two plates, one on each side—prevents dust, dirt, residue from grease, or any injurious foreign material from entering the raceway. It makes a motor bearing which runs free at all times because of the lack of channeling of grease, and obviates excessive pressures caused by over-greasing.

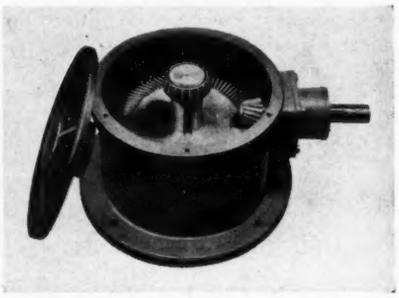
A motor bearing that is removable entire

As this bearing needs lubrication, it automatically uses only the fine oily part of the grease in the outside bearing chamber, or the upper bearing chamber in the case of a vertical motor. The inside bearing chambers on the horizontal motors, or the lower bearing chambers on the vertical motors, contain no grease that can be forced into the motor. When repairs require that the bearing be taken out of the housing, the fact that it is totally inclosed makes it easy to handle and prevents dirt from entering.

Speed Reducer Utilizes Vertical Spiral Bevel

A SPEED REDUCER of new type is announced by *D. O. James Manufacturing Company.* This unit features smooth, noiseless operation and several novel advantages of design. The gears are made of chrome nickel of spiral bevel type, to secure greater efficiency from the improved tooth form, which provides more teeth in constant contact and a greater tooth bearing or pressure area in each tooth of given size. High efficiency thus results, and a greater delivery of input power. Shafts are made of 40 carbon steel. Roller bearings are provided on both drive and driven shafts.

Where large ratios of reduction are required, this type of reducer is made integral with a planetary reduction unit, so that all ratios from 8 to 1 to 1,600 to 1 are available. They are made in sizes from ½ to 100 hp. A housing prevents oil leakage and keeps dust and dirt from filtering into the unit, forming a neat, compact drive for use whenever vertical (up or down) driving is required.



New unit motor has many possible applications in metallurgical plants

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Hardinge Expands District Facilities

The Hardinge Company, Inc., opened two new district offices on June 1, at 205 West Wacker Drive, Chicago, and 235 Montgomery St., San Francisco, respectively. The Chicago office will be in charge of C. W. Ankeny, with W. P. Penick in San Francisco. The Hardinge company specializes in the manufacture of metallurgical equipment, comprising Hardinge conical and rod mills, thickeners, clarifiers, and Ruggles-Coles dryers.

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Industrial Note

All castings now produced by the *Dodge Manufacturing Company, Ltd.,* and entering into its materials-handling equipment, are Meehanite processed.

Among Contributors To This Issue:

GEORGE C. BRANNER is State Geologist, Arkansas Geological Survey, with headquarters at Little Rock, Ark.

PHILIP S. SMITH has been associated with the United States Geological Survey since 1906, as assistant geologist, geologist, acting director, and chief Alaskan geologist.

LUCIEN EATON was for fifteen years superintendent of the Cleveland-Cliffs properties in the Lake Superior iron region. He has made notable contributions to the technique of mining in that region, and has been closely associated with progressive professional activities in his chosen field.

CARL TRISCHKA, an alumnus of Columbia School of Mines, has had a wide experience as resident engineer, examining engineer, or geologist with Cananea Copper, Shattuck Arizona, United Verde Extension, and other mining companies. He is at present chief geologist, Copper Queen Branch, Phelps Dodge Corporation, at Bisbee, Ariz. Mr. Trischka, who has contributed before to these columns, makes a hobby of the archeology of the Southwest.

CHARLES W. WRIGHT, who contributes, in this section, timely and helpful suggestions for the guidance of the graduating engineer, received his technical education in Germany and at the Michigan College of Mining and Technology. Executive and operating responsibility included eighteen years in charge of lead and zinc mines in Italy, and in connection with the introduction of American mining methods into Sardinia. He now occupies the important post of chief engineer of the mining division of the United States Bureau of Mines, to which he was appointed in 1918.

EDWARD KOEPEL has been closely associated with engineering progress in the Lake Superior copper region since 1880, when he first became associated with Calumet & Hecla. Between 1898 and 1909 he added to his experience in the erection and management of metallurgical units operated by important companies, being appointed mill superintendent for Copper Range in 1909, with technical control of the Baltic, Trimountain, and Champion plants, a position he now holds.

L. C. FOPEANO, of El Paso, Tex., was graduated from Emory and Henry College and the Colorado School of Mines. His metallurgical experience has covered operation and control work in the electrolytic and anode plants at Chuquicamata, Chile, where he also acted as plant metallurgist in charge of the research department, and assistant engineer of reduction. Until recently he was casting-house foreman and chief copper inspector at the El Paso plant of the Nichols Copper Company.

ARNOLD B. BLACK, a graduate of the South Australian School of Mines, is chief surveyor of Broken Hill South, Ltd. His article "Precise Shaft Surveying," presenting detailed descriptions of methods and appliances, reveals an important responsibility that devolves on the mine surveyor when shaft sinking and timbering are in progress — a responsibility frequently overlooked.

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J. Parke Channing motored to New York recently from Berkeley, Calif.

Raymond Brooks has moved his office to the Chrysler Building, New York City.

Charles A. Mitke, who recently returned to the United States from Australia, is expected in New York shortly.

Ludwig Vogelstein, chairman of the board of directors of American Metal, returned from Europe to New York on May 23.

R. F. Mehl, superintendent of the division of physical metallurgy of the Naval Research Laboratory, has been appointed assistant director of research for the American Rolling Mill Company.

Col. Percy S. Barbour calls attention to the fact that the copper reduction works at Hayden, Ariz., belong to A.S.&R., and not to Phelps Dodge, as was recently erroneously printed in his article on world copper-refining capacity.

S. C. Kreyns, formerly assistant smelter superintendent of the American Smelting & Refining plant at Hayden, Ariz., has joined the staff of Braden Copper, in Chile. He is succeeded at Hayden by **B. A. Berryman,** who has been transferred from the A.S.&R. smelter at Tacoma, Wash.

H. M. Lawrence, until recently with the International Agricultural Corporation as mining engineer at its Tennessee properties, has joined the staff of the American Standards Association. Mr. Lawrence was for several years in charge of investigations in the beneficiation of Florida phosphate for the United States Bureau of Mines. Previously, as metallurgist for the Kennecott Copper Corporation in Alaska, Mr. Lawrence was closely connected with the development of ammonia leaching and flotation processes for copper carbonate ores.

Carl N. Anderson writes from Baxter Springs, Kan., in regard to Mr. Keiser's article, "Placer Gold in Peru," published in a recent issue, in which credit for revealing the potential wealth of the Inambari watershed is given to William B. (Swift Water Bill) Gates. "The statements as to this locality are so alluring," he says, "that I am sure many of your readers have wondered as to their authenticity. I am therefore sending you a photostat of a page of the *Klondike News* of April 1, 1898, which speaks for itself regarding Mr. Gates." An excerpt follows: "Wm. C. Gates, better known as 'Swift Water Bill,' . . . is probably the best judge of the richness of a gravel bed or the value of a dump in all the Klondike, and his services as an expert in this respect are in great demand. It was he who discovered and located the first claim on Sulphur Creek, and thereby enriched the country by many millions. He was likewise the first man to discover that No. 13 Eldorado was worth countless thousands, and it was through him that the many partners in No. 13 have all accumulated fortunes."

Alaska and the Geological Survey

To the Editor of "E. & M. J.":

Your editorial in the issue of May 11, 1931, commends the proposed procedure of the United States Geological Survey, whereby the results of its investigations in the interests of the Alaska Railroad will be made available "without reference to Washington" and whereby another representative of the Survey will be maintained at Anchorage throughout the year. The Geological Survey appreciates your approval and hopes that your prophecy that "the outcome will greatly enhance the value of the work" is correct. Frankly, however, the plan is undertaken with some trepidation because it has certain inherent weaknesses that may not lead to its working out as well as you and the rest of us hope.

Before discussing these weaknesses, let me freely admit that long delays have occurred in the issuance of some Geological Survey reports. Some of these delays have been unwarranted. Even our severest critics, however, must realize that most of these delays have originated through intention to better our product. Eliminating unwarranted delays, it follows that rapidity of publication necessarily implies less critical consideration, revision, and testing. The question of the desirable degree of rapidity therefore becomes one of balance, on which no two individuals are likely to agree. Is work that is of 60 per cent quality delivered within a week better or worse than work of 75 per cent quality delivered in a month, or than work of 95 per cent quality delivered in two years? I don't see that there is any single answer to that question, because I am sure that it would be impossible to agree on the rating for quality or on the length of time that is reasonable under different conditions.

To even the insider the Geological Survey procedure, by which a manuscript that has been completed by its author goes through innumerable subsequent stages of review, may on his first experience seem unduly complicated. He may ask, Why should the manuscript be read by the division chief, the branch chief, the specialist on any of the subjects discussed, such as oil, water,

physiography, glaciation, or petrology; the committee on geologic names, the illustrators, the map editors, and the text editor? Why should the galley and the page proof be read and reread not only by specialists in the art of book-making but also by the appropriate scientists? Obviously, the only purpose of this lengthy procedure is to assure a high quality of product, and even with these safeguards slips and errors occasionally get by. Eliminate any of the steps, and there is likelihood that some really vital considerations may have been overlooked. The Alaskan branch will indeed be fortunate if statements published within a few weeks after the field work on a project is completed measure up to the average requirements — they certainly can be expected to add little to the prestige of the Survey's regular reports except in the matter of speed.

The maintenance of Geological Survey members at stations in Alaska throughout the year is by no means a new thing, for at present the Alaskan branch has local offices at both Juneau and Anchorage, where engineers are stationed continuously, and until a few years ago it had a geologist stationed for several years at Anchorage. The plan of maintaining a geologist at Anchorage in connection with the railroad work contains elements of risk, as well as of good. The geologic and economic problems of the railroad region are extremely diverse. The deposits are of many kinds: lodes of gold, silver, lead, copper, antimony, zinc, quicksilver, and tungsten, and placers of gold and platinum, have in the past yielded some production, and some of the non-metalliferous deposits may be utilized in the future. Explanation of the occurrence of economic deposits will demand skill in stratigraphy, petrology, chemistry, and many other branches of geology. Obviously, no individual who could be selected for the Anchorage post will possess specialized knowledge in all these subjects, and many of the problems brought to him must either be answered to the best of his incomplete knowledge or longer delayed while the matter is referred to a more competent authority in the Geological Survey or elsewhere. Few persons who have not experienced the benefits afforded by being part of the Survey organization can realize the help and stimulation that consciously or unconsciously comes through that association in work and play with the largest working force of geologists and related scientists in this country — a geologic faculty that certainly is not surpassed by any other institution of its kind in this country and probably not by any other in the world. The realization of the effectiveness of utilizing this whole machine has deterred the Survey from maintaining many scattered local stations as centers for its geologic work. It is the possibility that the local geologist may lose the full strength of the organization, of which he is a part, that makes those responsible for the administration of the work connected with the mineral investigations in the vicinity of the Alaska Railroad apprehensive that the drawbacks of establishing a lone geologist in Anchorage may overbalance the benefits that unquestionably will result. Individually we speak of our own knowledge or lack of knowledge, but as members of an organization our utterances take on added authority, especially if the organization is one like the Geological Survey, which has laid down a procedure that aims to make sure that its best is added to our best to benefit the combined product. You conclude your editorial with an apt quotation, so that it may not be amiss for me to support this part of my thesis in a similar manner by quoting the old saying "United we stand, divided we fall."

Washington, D. C. PHILIP S. SMITH.

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How Long Does an Ore Deposit Take to Form?

To the Editor of "E.&M.J.":

The question has often been asked, "How long does an ore deposit take to form?" But, so far as I know, the answer has never been given. Some years ago, however, I had the opportunity to watch the deposition of ore under circumstances somewhat like those under which we believe the soft orebodies of the Michigan iron ranges to have been formed. These orebodies consist of soft, hydrated hematite, and are supposed to have been formed by solutions percolating downward through overlying, iron-bearing strata. The solutions dissolved some of the iron in these strata and deposited it again lower down, when conditions were favorable, either in open cavities or as replacements of silica.

In 1916, a sublevel was opened in the Cliffs Shaft mine, at Ishpeming, Mich., 150 ft. below the contact of the iron formation with the overlying water-bearing, glacial drift. Above this sublevel was hard, specular hematite, but it was not mined, because of the wet sand above. Water percolated through the iron formation and ore, and formed a deposit of soft, muddy hematite of the consistency of butter in one of the drifts of the sublevel. This ore was held back by a small dam, and the water overflowed, in much the same way as is supposed to have happened in the troughs in which the large orebodies are found on the Marquette range. The flow of water remained practically constant at 30 gal. per hour.

I watched this deposit grow for thirteen years, and at the end of this period I measured its extent and took a sample, which I had analyzed. Much to my surprise I found that the sample was nearly 95 per cent uncombined water! In its natural state the sample weighed 78 oz., and, when dried at 212 deg. F., it weighed 4 oz. This 4 oz. had the following composition: Iron, 32.50 per cent, phosphorus, 0.105, silica, 8, manganese, 12.43 per cent. Loss by ignition, 21.4 per cent. Loss by ignition was mostly combined water, so that the 78 oz. of original sample contained only 3.14 oz. of mineral matter, almost exactly 4 per cent. The proportion of manganese is unduly high, but this is owing to the fact that the manganese minerals in the hard ore, which carries about 0.75 per cent manganese, are more readily soluble than the iron minerals.

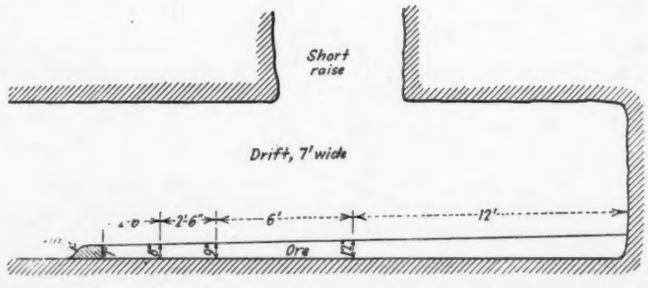
The deposit of muddy ore measured 142 cu.ft., and the sample, containing 3.14 oz. of mineral, measured 108 cu.in. Therefore the deposit contained 2272 x 3.14 oz., or 446 lb., or 0.20 long ton of mineral. This mineral carried 44.93 per cent combined iron and manganese; 0.20 ton of 45 per cent ore is the equivalent of 0.15 ton of 60 per cent ore.

In thirteen years 30 gal. of water per hour amounted to 3,416,400 gal., and this amount of water precipitated the equivalent of 0.15 ton of 60 per cent iron ore. On this basis it would take practically 22,776,000 gal. of water to produce one ton of 60 per cent ore.

If it is assumed that the rainfall, evaporation, runoff and seepage, when the ore deposits were being formed, were approximately the same as they are now, the minimum time required to form some of our large orebodies can be calculated from the flow of water encountered in mining them. For instance, an orebody containing approximately 4,000,000 tons had a flow of 180 gal. of water per minute, when mined. Now, 180 gal. per minute is 94,608,000 gal. per year, and would precipitate 4.16 tons of ore per year. Therefore nearly a million years was needed to form this orebody. Another orebody containing 13,000,000 tons had a flow of only 250 gal. per minute, and on the same basis required two and a quarter million years for its formation. What relationship the flow of water under natural conditions bears to that when mining is being carried on I do not know, but one may logically assume that it would be a rather small percentage, and the time required for the formation of the orebody should be correspondingly increased. Possibly, however, the longer time in which the water was in contact with the minerals might compensate to some extent for the smaller flow.

I realize that these figures have little, if any, practical value, but occasions when the workings of nature can be measured are so rare that it seems possible that they may be of some interest to students of geological theory.

London, England. LUCIEN EATON.



Secrets of Success: for the Graduate Engineer

To the Editor of "E. & M. J.":

The condition in the mining industry today is such that there is keen competition for the subordinate positions at the mines. To be successful in getting or holding a job, the young engineer must do his utmost to make himself efficient. His future earning power is more likely to depend upon a background of sound experience than upon his brilliancy as a student.

Every old engineer could name a list of "don'ts" that would help the aspiring youth in his career, but the "do's" are usually more effective, such as "do it now," even though you have to work overtime. Another good rule is "do it together"; be ready to help the other man whether subordinate or superior, and don't worry about who gets the credit. Teamwork with his associates will go a long way toward advancing the young engineer.

Instead of giving more advice, it may be better to refer to some specific cases and let the mining engineer just starting out on the highway to success or failure form his own ideas.

Case I: The owners of a group of copper prospects engaged a young mining engineer to superintend developments. He made a study of the outcrop, consisting of a garnetiferous gangue rock at the contact of limestone and granite and containing chalcopyrite altered at the surface to malachite, azurite, cuprite. The surface exposure was extensive, and it gave the impression of a large deposit of rich ore. This engineer recommended the driving of a 2,200-ft. tunnel along the contact to intersect the deposit 1,000 ft. below its surface exposure, and at the same time to explore the contact. Tentative tonnage estimates of the possible ore reserves that would be developed by the tunnel were based on the extent of the deposit as exposed at the surface. A 100-ton shipment of the ore was sent to a smelter for a treatment test, and the results were such that the company felt warranted in erecting a smelter so as to be ready to treat the ore when developed.

Two years were spent driving the tunnel in this hard garnet-epidote contact-rock, and in erecting ropeways and the smelting plant. The engineer was required to go back East to help raise the capital to complete the project. Because, largely, of his inexperience and the enthusiasm of the promotors, he had faith in finding an orebody in depth. No ore was found. The property was abandoned, the investors lost their capital, and the engineer, discredited alike by both promotors and investors, was left without a position.

Case II: A foreign mining company anxious to improve its mining practice engaged an American graduate engineer with a few years' experience to take charge of a mine. He was full of ideas as to improvements, changed the mining method from horizontal cut-and-fill to the rill system, and wherever possible introduced the shrinkage method with wholesale rather than selective mining. The sorting of waste in the stopes to increase the grade of the ore sent to the mill was abandoned. Larger ore cars, loading machines, and electric haulage was introduced, and the capacity of the milling plant was doubled. Although twice the tonnage was treated in the mill, the ore content was lower and the output of concentrates was only slightly increased. Costs naturally increased considerably and profits gradually disappeared. The owners realized their mistake, and the mine is again being operated at a profit by the old system of selective mining and hand shoveling. The large mine cars and loading machines are on the scrap pile—so is that American engineer.

Case III: A graduate engineer was given a position as shift boss at a large copper mine in South America. He was a studious fellow of the efficiency-engineer type. He introduced a bonus pay system, analyzed the daily records, and encouraged the men to improve results and thus their pay. He always thought ahead to see that the workmen had plenty of tools in proper condition and other supplies on hand, and instead of driving the workmen and swearing at them, he would take a shovel or machine drill and help them if necessary. He was always willing to have the men express their opinions regarding the work, and encouraged them to do so. The mine superintendent, noticing the improved results from his section, made casual inquiries of the workmen as to their boss and found that they all not only enjoyed working under him, but had confidence in always getting a square deal from him. After he was promoted to mine foreman, he demonstrated that forethought and pleasant relations with the workmen resulted in greater efficiency and lower mining costs. Today he is the general manager of the company.

SUGGESTIONS

Keep out of any mine-promoting until your judgment is backed by many years of experience. Put no trust in the extension of an undeveloped orebody. Base plant expenditures only on tonnages of ore in sight.

Selective mining, where possible, is usually more profitable and less risky than wholesale mining methods. To change any general mining practice not only involves great technical problems but is a most difficult undertaking because of the opposition of workmen and foremen to new methods and machines; and if their opinions are not considered, trouble is the inevitable sequel. The best way to introduce a change is to get the shift boss or foreman to think about improving results, see that he is the one to propose any changes in practice to his superiors, and then give him full credit for the suggestions!

Know the workmen under you personally and take an interest in them. Keep detailed records of work accomplished per man-hour and per unit of supplies consumed. Try to improve these results by eliminating the causes for time wasted, such as waiting for tools, supplies, empty cars, hung-up chutes, and other delays.

There is an economic limit of production at which any mine can produce at a minimum cost, and attempts to go above this limit often result in increased costs. Certain economies, however, are always possible regardless of output; this is being demonstrated today at certain copper and zinc mines that have curtailed their output from 20 to 40 per cent and also lowered the cost per pound of metal produced. This is due to more careful selection of ore mined and greater efficiency from workmen because of better supervision. During periods of high metal prices underground developments should be pushed so as to permit flexibility in mining and curtailment of development work during periods of low metal prices.

As the graduate engineer is often handicapped by narrow or very limited experience, he should whenever possible visit other mine and mill operations, carefully observing the methods in use but keeping his thoughts to himself. For many reasons, it is a wise practice not to make notes on a mine or plant until after the visit. Keep up with the mining literature, particularly the publications by the United States Bureau of Mines and the technical press, and thus learn where information, when needed, may be obtained. This knowledge, together with the engineer's ability to use his "thinking cap" in the execution of any undertaking, will determine the amount of salary he is to receive.

CHARLES W. WRIGHT.

Washington, D. C.

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Obituary

Lewis Orvis Evans, authority on mining law, and for many years general counsel for Anaconda Copper Mining, died on May 30 in Los Angeles. Mr. Evans was 59 years old.

Ernest Fritzberg, general manager of Trout Mining, died at his home in Philipsburg, Mont., on May 30. Mr. Fritzberg was 45 years old, and had been active in the manganese mining industry for the last twelve years.

Eugene Thomas, of Wallace, Idaho, died on May 11, in a Wallace hospital, after a long illness. He had been connected with several companies operating in Coeur d'Alene district. At the time of his death, at the age of 73, Mr. Thomas was engaged in developing New Hope Mining, of which he was the founder.

Barry Searle, Sr., died in May at his home in Montrose, Pa. He was 70 years old, and had seen nearly 50 years of service in the mining industry all over the world. Among the posts held by Mr. Searle was that of manager of Crown Mines, in South Africa. He spent many years as a consulting engineer.

Arthur P. Heinze, one of the organizers of the United Copper Company, died on May 18, at his home in Seattle, Wash. He and his late brother Augustus formed the company at Butte, which they sold to Anaconda Copper Mining. Mr. Heinze, who was 66 years old, was interested in a silver mining enterprise at the time of his death.

Bulkeley Wells, according to Associated Press report, died by his own hand in San Francisco on May 26, having suffered financial reverses. He was identified with the Smuggler Union Company and other mining enterprises, and served (1918-19) as president of American Mining Congress, following his retirement from the United States Army with the rank of brigadier general in 1917.

NEWS OF THE INDUSTRY

Lack of Money Hampers California Gold Mines

Interest in gold mining in California, continues to increase, but, although numerous options are in the air, only a small amount of real money is going into the industry, and money for this purpose seems hard to get. A. R. Archibald, of Grass Valley, is reported to have merged several gold properties in the Nevada City-Grass Valley districts and to have formed California-Juneau Mines. The Central Consolidated, New England, Banner, Norambagua, Perrin, and Slate Range properties, as well as some placers, are included in the new set-up. Promises are made that activities are to begin at the Central Consolidated and New England.

The Alcalde, west of Grass Valley, is reported to have been bonded by W. M. Cady and T. Berger. The Ford claims, near San Andreas, are reported to have been sold by Calaveras Development to Los Angeles interests. Arbona, near Tuttletown, has been bonded by W. E. Campbell. The Bromley property, north of Jamestown, has been bonded to E. T. Preble. Negotiations are rumored for the control of the South Eureka mine, an old Mother Lode property, and rumor likewise states that negotiations are about to be consummated for the Yellow Aster property, in the Randsburg district.

Russell Kent Mining has completed a headframe and has started shaft sinking at the Courtwright property, west of Jackson and west of the Mother Lode area. Mining work at such a distance from the exploration zone dominated by the Mother Lode will be watched with interest.

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Calumet & Hecla Cuts Wages; Quincy Follows Suit

Calumet & Hecla Consolidated announces a cut in wages of 10 per cent, effective June 15 at its properties in Michigan, affecting underground and surface workers receiving in excess of $3.25 per day, and a reduction of 15 per cent in salaries in excess of $200 per month. The three operating shafts of the Osceola lode branch were shut down June 1. There was a shifting of forces to take care of men with dependents as far as possible. Most of those laid off were single men.

This is the second wage cut since the depression in the copper industry set in, the first being made July 1, 1930, when wages were reduced to the rates existing prior to the raise of March 1, 1929. The operating schedule will continue on the basis of four days per week.

Quincy Mining, also a Michigan producer, announces that it will return to the wage scale paid in 1921, when copper was selling for 2¾ cents more per pound than at present. This will mean various readjustments in wages and salaries. Quincy is operating with a comparatively small force, and every effort will be made to keep the mine open. A further small reduction in number of men employed is probable.

Tri-State Turns to Central Milling; Eagle-Picher Plans Large Unit

Out of the depression of 1930-31 a changed operating method is expected to emerge in the Tri-State zinc-lead district, which will enable the local operators to produce zinc and lead concentrates more economically and in turn allow the mining of the lower grades of ore, of which huge quantities are available. Plans are being completed by the engineering staff of Eagle-Picher Mining & Smelting, subsidiary of Eagle-Picher Lead, for the replacement of the Netta mill, at Picher, Okla., with a new concentrator, capable of handling 3,600 short tons of ore a day. The company has obtained permission from the Indian Department and individual landowners of a large number of fees to mill the ores from these separate allotments and fees at the Netta mill.

In the past the Tri-State district has chiefly operated mills with a capacity of from 25 to 40 tons an hour. These plants have usually operated on a ten-hour shift. In the future mills are expected to be able to handle from 100 to 200 tons of ore an hour and will be operated continuously.

Successful treatment of ores from numerous fees, with an equitable sampling arrangement which allows for the fair distribution of royalties to landowners, has been developed at the Bird Dog mill of Commerce Mining & Royalty Company, the first of the new and larger units in the district. It was recently described in *Engineering and Mining Journal* by Elmer Isern, metallurgist of the company, and the designer of the mill.

Ores from four allotments are being milled at the Bird Dog mill, and permission has been granted by the U. S. Department of the Interior to allow the milling of ore from two additional allotments. In all, this mill has abut 2,500 acres of land from which to draw milling ores. To handle these new allotments additional ground-ore bins and an addition to the automatic sampling plant will have to be built.

The new mill of Eagle-Picher will have automatic weighing and sampling devices similar to those at the Bird Dog mill. Eventually, the mill expects to handle the ores from fees, on which there were formerly some twenty or more smaller milling units. Cost of the Bird Dog mill was $305,000. The new plant of the Eagle-Picher will probably cost between that amount and $400,000.

The building of the Bird Dog mill by Commerce was to a certain extent an experiment looking towards centralized milling, and according to officials has been successful from every viewpoint. Whether the company will continue with the plan of centralized milling and construct two or three additional units to mill the ores from its vast holdings and eliminate the twelve or fourteen smaller units now in force has not been definitely decided.

Costs at the Bird Dog mill have been low. Because the mill was completed just as the depression arrived, it has not been operated at capacity and consequently just how low costs can be reduced is not known. Since starting, the mill has been operating on ten-hour shifts and in recent months only every other week.

St. Louis Smelting & Refining, National Lead subsidiary, which has a large new concentrator in the West Baxter Springs section, has been drawing plans for some months looking toward the enlargement of this mill and the addition of automatic sampling devices so that ore from numerous fees can be milled at the one plant. When this plant is reopened it is expected to operate on a continuous basis.

Continuous operations are conducive to lower costs. Plants that have been operated on such a basis have shown lower costs than plants operating single shift. Eagle-Picher has made such an experiment at one of its plants. Tri-State producers, realizing that zinc prices may remain low, are changing their mining and milling plans to meet changed conditions.

The Tri-State district has produced as much as 16,000 short tons of zinc concentrate a week over long periods. At such times, more than 160 mills were operating. Only 34 mills are now running, producing about 5,100 tons of zinc concentrates a week. If centralized milling becomes the fashion and prices stay low, the future may see about twelve large concentrators producing the entire output of about 10,000 tons of concentrate a week, from ores averaging 4 per cent zinc. Although few of the mills now in operation are losing money, they are averaging a recovery of about 8 per cent zinc from the ore handled. Most mines have to handle this higher-grade material to make both ends meet. Eventually, of course, these high-grade orebodies will be exhausted. Although vast quantities of 4 per cent zinc ore are available in the district, it is doubtful if small units could treat it profitably with prices at or below $30 a ton of concentrate. The low-grade deposits probably can be treated by larger units, however.

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Build Mill at New Year Mine

Mammoth Arizona Gold Mining is building a 200-ton mill at its New Year mine, adjoining the historic Mohawk and Mammoth mines, about three miles from Mammoth, Ariz. The mill equipment was purchased from the Morning Glory mine, at Patagonia, Ariz. Recent underground development work at the mine includes the sinking of the main shaft to a depth of 515 ft., and drifting on several levels. Activities at present are being centered on the 425 level, where 160 ft. of ore has been opened, carrying gold, lead, molybdenum, and vanadium. Sam L. Houghton, mining engineer, is in charge of operations at the New Year mine.

Remodel Copper Queen Furnace to Use Natural Gas

At the Copper Queen smelter of Phelps Dodge Corporation, Douglas, Ariz., one reverberatory furnace was shut down on June 1, to be remodeled and equipped for the use of natural gas. According to the latest dispatches, the natural gas being piped from El Paso will be available for use about June 15. Work on the new reverberatory furnace at the Calumet & Arizona smelter is rapidly nearing completion. The furnace is expected to be in operation at the scheduled time.

As to the many rumors of an impending shutdown of both Douglas smelters, no authentic news is available, but there may be a further curtailment of production, with a shorter week basis in order to keep as many men employed as possible.

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New Pumps for Eureka Standard

Installation of additional pumps, with a capacity of 1,200 g.p.m., is being made at the Eureka Standard gold property, controlled by Tintic Standard, near Dividend, Utah. The shaft has reached 1,400 ft., but a crosscut will not be driven to the vein until the pumps are installed. The vein is expected to be about 600 ft. from the shaft. Present production is coming from the 1,100 and 1,300 levels.

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New Mill for Nevada City

Federal Consolidated Mining, of which J. M. Hoff is manager, is constructing a 100-ton flotation mill on its St. Louis property, near Nevada City, Calif. The mill consists of a ten-stamp plant to which are being added a duplex Dorr classifier, in closed circuit with a 4x10-ft. tube mill, a four-cell Kraut flotation unit, a 10x8-ft. thickener, and a 4x6-ft. Oliver filter. The plant is being rapidly completed.

Several mining claims along Deer Creek near the Murchie mine have now been consolidated by the company. The claims are the Federal Loan, Constitution, Cyane, Le Compton, and the St. Louis. A gold orebody has been opened and some shipments have been made to a smelter pending the completion of the flotation mill.

■

Walker Cuts High-Grade Ore in North Shoot at Depth

Development on the lower levels of the Walker Mining property, near Spring Garden, Calif., continues to show ore of better than average grade, according to J. R. Walker, president of the company. About 32 ft. of ore in the north orebody has been exposed in a crosscut 400 ft. vertically below the 700 or main tunnel level. On the 700 level the north orebody is 1,600 ft. long and in places 125 ft. wide. The grade of the ore in the new crosscut is about 4 per cent copper, compared with a mine average of from 1.5 to 2 per cent. The Piute orebody on the 1,000 level shows 10 ft. of milling ore, with a rich streak of bornite. Present production cost at the Walker property is about 8.9c. per pound of copper. All officers were re-elected at a directors' meeting held in Salt Lake City, on May 26. The tailings pond will be raised two feet and 700,000 ft. of timber on the property sawed up for lumber.

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Build Tram at Yankee Mines

A 4-mile cable tramway will be built at the Yankee Mines property, in Mary Ellen gulch, American Fork district, Utah, according to A. H. Means, manager of the western mining department of American Smelting & Refining, which controls the property. This property has been shipping about 50 tons of gold-copper ore daily by horse-drawn trucks to the main road at Deer Park. The tramway will eliminate the wagon haul of 8 to 10 miles and will make possible year-round shipments. It will be built by Riblet Tramway Company, of Spokane, Wash., will have a capacity of 10 tons hourly, and will take about four months to complete. Starting at an altitude of 9,200 ft. at the mine, it will cross the ridge separating Mary Ellen and Major Evans gulches at 10,200 ft., and descend to 6,000 ft. at Deer Creek.

Headframe and power plant at south main shaft, Kansanshi mine, Northern Rhodesia

No Hope for Silver Confab, Hoover Informs Smoot

Any hope that might have been entertained for a conference of silver-producing and silver-consuming countries in the near future has been killed by a telegram sent to Senator Reed Smoot, of Utah, on June 2 by President Hoover. Ever since the decline in the price of silver began, late in 1929, there has been a demand for a conference to stabilize the price of the once-precious metal. At the time of the International Chamber of Commerce meeting in Washington, this May, the friends of silver were successful in having a resolution passed that advocated the holding of such a conference. Since then, however, it has become evident that few countries are willing to risk taking the initiative in calling the conference. Mr. Hoover's message to Senator Smoot follows:

"I am now able to inform you that informal discussions among nations, some of whose participation is vitally necessary, develop the fact that they do not consider this a proper time to call an international conference on silver and would oppose holding such a conference now."

The assumption is fairly general that Great Britain was the most important opponent of the conference. At the International Chamber meeting, the British delegates expressed a belief that silver's importance as a monetary unit was no longer sufficient to warrant concerted action on its behalf. More recently, Sir James Salter, international authority on currency, speaking before the Academy of Political Science, in New York, predicted that any artificial bolstering of the price would end in disaster. If silver is to resume its place in the monetary system of the world, he said, the demand must come because of a need for additional currency and not because of the needs of silver producers or users. Although half of the world's population uses silver, he added, only 10 per cent of the world's trade is ordinarily done by those countries.

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Lead Producers Confer at Salt Lake Meeting

Mining operators representing a large part of the country's lead-zinc production met during the last week in May in Salt Lake City, Utah, for a series of conferences, the purpose of which was not divulged to the press. Those present were: F. H. Brownell, chairman of the board of American Smelting & Refining; H. Y. Walker, vice-president in charge of smelting of the same company Clinton H. Crane, president of St. Joseph Lead; I. H. Cornell, vice-president and sales manager of St. Joseph Lead company; F. W. Bradley, president of Bunker Hill & Sullivan Mining & Concentrating and Stanly A. Easton, vice-president and general manager of Bunker Hill & Sullivan.

D. C. Jackling, president and managing director of Utah Copper, was in Salt Lake City at the same time on a trip of inspection and also for the purpose of confering with Mr. Brownell concerning smelter contracts. Operations at Utah Copper will not be stopped unless something "calamitous" happens in the mining industry, according to Colonel Jackling. Production will be maintained on a basis of 40 per cent of capacity.

Union Minière Plans Town for Western Area

Although actual development work on the western or Musonoi group of mines of Union Minière du Haut-Katanga has been suspended because of depressed metal markets, actual construction of a new city, to be known as Jadotville, will be started on July 1. Jadotville will be 200 km. west of Panda, Belgian Congo, along the Lobito Bay railroad. A company with a capitalization of 50,000,000 fr. has been formed to build the town, of which Union Minière owns 50 per cent.

Jadotville, named after Jean Jadot, chairman of Union Minière, is within 30 km. of the N'Zilo Falls, which will furnish power for the metallurgical plants that will eventually be built there. According to our Brussels correspondent, Union Minière has developed 15,000,000 metric tons of ore, averaging 8 per cent copper, in its Musonoi group—indicating a copper content of 1,200,000 metric tons. A metallurgical plant with a capacity of 50,000 to 60,000 tons of copper annually, another one to treat tin ore, and a third to treat the gold-platinum ores from the Ruwe property are being planned. At present, however, only the town will be built, because of depression in the metal markets. Jadotville is expected to be a commercial center for some of the Northern Rhodesian copper mines as well. Copper from the Kansanshi mine of Rhodesia Katanga will probably be connected with the Lobito Bay route by a branch line to Jadotville.

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McIntyre Reserves Higher, But Grade Drops

McIntyre Porcupine Mines, operating in the Porcupine district, Ontario, reports an increase of more than 200,000 tons of ore in reserves to 2,562,465 short tons, averaging $8 in gold per ton, on March 31, 1931. At the close of the previous fiscal year, the reserve was 2,345,676 tons, averaging $8.30 in gold per ton. Most of the ore—more than half—is in the company's Jupiter claims. A feature of the development work has evidently been the failure to open much new ore on the bottom levels of the mine. Although nothing is specifically said about this in the report, the material extracted from below 3,000 ft. was very low grade and the drifting done on the Nos. 13, 14, and 15 veins at depth showed poor results. However, a crosscut on the 3,750 level southeast into the Platt Vet ground has been used for diamond drilling to the south, with indications of ore deposits assaying well above mine average. As this area is separate from the Pearl Lake shear zone, from which all the McIntyre ore has been mined in the past, these discoveries are regarded as of major importance by the management.

According to the report, the new mill is expected to be handling 1,500 tons daily by June 1 and to be gradually brought up to 2,000 tons daily within the following sixty days. This new mill is at the No. 11 shaft and replaces the old plant, situated on three different points on the property. Construction was started on Aug. 1, 1930. Milling costs in 1930-31 were higher than in the previous year. Removal of machinery to be placed in the new mill upset ordinary routine and decreased tonnage and recovery.

Roan Antelope's new mill, in Northern Rhodesia

Ahumada Lead to Close Mines; No New Ore Developed

On June 30, Ahumada Lead will cease operations at its Los Lamentos property, in Chihuahua, Mexico. O. R. Whitaker, president of the company, states that the development work undertaken in previously unexplored territory has failed to find the new orebodies that had been hoped for. As much of the known ore is in the flooded No. 8 level, and as the mine had been operating at a considerable loss, no alternative existed in the face of present depressed metal markets but to close, despite the fact that the entire Los Lamentos district is dependent on the mine. Production in the first quarter of 1931 was only 1,593,176 lb. of lead, or about 50 per cent of recent normal production. The company's finances, Mr. Whitaker also says, are virtually exhausted.

Ahumada Lead has had a checkered career in the last few years. From the formation of the company in 1921 up to 1926, the mine had prospered, dividends were paid, and production reached 16,000 short tons of lead and 200,000 oz. of silver annually. Then, in cutting a station on No. 8 level, a large flow of water was developed. Water has proved Ahumada's nemesis, for time and again the operators have been driven out of the No. 8 level workings, where the continuation of the ore has been proved. Pumping equipment installed in the property has a capacity of about 3,000 g.p.m. daily and its operation is so expensive that whenever lead drops below 7c. a pound, profitable working of the No. 8 level is almost impossible. Early in 1930, the pumping plant was shut down, and since then the company has had to confine itself to mining ore above water level. These reserves are virtually exhausted. Ore from the property is shipped to the American Smelting & Refining plants at El Paso, Tex., or Monterey, Nuevo Leon. Average grade is about 20 per cent lead and 3 oz. of silver per ton.

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Start Work on Aldermac Mill

Construction has been started of the new 500-ton concentrator of Aldermac Mines, in the Rouyn district, northern Quebec. This plant will produce a high-grade pyrite concentrate, as well as a copper concentrate. The pyrite concentrate will be utilized in the production of sulphur by the new Freeman roasting process. Cost of the plant is estimated at about $400,000. Reserves in sight at the property are sufficient for fifteen years of operation at 500 short tons daily. Provision is made for raising capacity to 1,000 tons daily should demand develop. Copper concentrate will be shipped to the Noranda smelter at the rate of about 40 to 50 tons a day. Pyrite-concentrate output will be about 300 tons daily.

Rand Mines Group Showed Better Results in 1930

The annual report of Central Mining & Investment, which controls one of the largest group of gold mines on the Witwatersrand, indicates that continued progress is being made in the great South African gold field by constant research and experiment. Because of the magnitude of operations, many of the improvements, although small in scope, have effected notable savings. During 1930, the report, which has just recently been published, states that the properties in the Central Mining-Rand Mines group treated 12,988,900 short tons of ore, from which £17,561,315 in gold, silver, and osmiridium was extracted. This tonnage is 97.3 per cent of normal milling capacity of the properties and was made possible by an increase of 5.6 per cent in the number of colored employees—illustrating the importance of black workers to the Rand mines.

Development footage driven increased 47,098 ft., or 9.9 per cent, and the total working profit was up £115,789. The drop in the price of mining supplies reduced the cost of stores by 3.7d. per ton of ore treated. Average cost of producing an ounce of gold in 1930 was the same as in 1929—63s. 8d. Total development footage driven was 524,733 ft., or 99.4 miles.

The mines of this group—which includes such notable producers as Crown Mines, New Modderfontein, East Rand Proprietary, Modderfontein East, Consolidated Main Reef, Geldenhuis Deep, City Deep, and Durban Roodepoort Deep—reduced the average gold content of tailing during the year from 0.312 dwt. per ton to 0.307 dwt. per ton, despite the increase in tonnage treated. The improvement results largely from selective grinding, now used at four of the reduction plants. In these particular units, tailing loss has dropped from 0.318 dwt. to 0.285 dwt. per ton. Additional gold recovery at these plants is £26,362 per annum at an operating cost of £14,000—a saving of £12,000 annually.

During 1930, the Crowe-Merrill vacuum zinc-dust precipitation process was installed in the three Crown Mines reduction plants in place of the zinc extractor boxes previously used. Although little difference exists in operating costs between these two methods, the Crowe-Merrill method obviates the retention of a considerable stock of gold in the extractor boxes. So far, more than 29,000 oz. of gold has been recovered from the discarded zinc boxes. The capacity of the western plant of East Rand Proprietary has been increased 20,000 tons monthly by adding three tube mills, a new classification plant, and twelve more corduroy tables. The new 6,000-kw. turbo generator, installed in this property's power station, has cut costs by £9,750 annually. Additions were also made to the milling plants of Modderfontein East, New Modderfontein, Geldenhuis Deep, Durban Roodepoort, and Glynn's Lydenburg.

Ahmeek Mill Remodeling May Be Completed This Year

Remodeling of the units treating Kearsarge lode rock at Calumet & Hecla's Ahmeek mill, at Hubbell, Mich., is in progress. One unit has been completed and the second is nearing completion. Hope is expressed that the work on the remaining units will be finished this year. The change in the flowsheet consists in regrinding all tailing from the jig to pass 35 mesh and treating it on Fahrenwald flotation machines.

Details omitted, the flowsheet of the remodeled unit is as follows: The $\frac{3}{8}$-in. stamp product goes to trommels having a $\frac{3}{16}$-in. hole. Oversize is jigged, crushed in rolls, and returned to the trommels. Undersize goes to a Dorr classifier, from which overflow goes to the Fahrenwald flotation machine. The sand is jigged, this giving a concentrate and a tail, which is ground in an 8x6-ft. Hardinge mill, in closed circuit with a Dorr classifier and a "bleeder" Wilfley table. The purpose of the latter is to prevent the heavy copper from building up in the mill-classifier circuit. Classifier rake product, containing the heavy copper, passes through a launder in which an hydraulic action is set up and over the Wilfley to remove the copper, and thence back to the grinding mill. Overflow from this classifier goes to the flotation machine, to join the overflow from the classifier following the trommel. The flotation machine makes a concentrate and a tail, the latter going to a third Dorr classifier. From this, overflow goes to waste, the rake product being tabled to produce a concentrate and a tailing, which is wasted.

Underground equipment in Calumet & Hecla's Osceola lode shafts, which closed June 1, is being brought to surface. The Osceola is a low-grade vein, profitable only when copper commands a much higher price than at present, so it is considered likely that the shafts will remain idle for a long period. The last shutdown of this branch was in 1920, the shafts remaining closed for almost five years. At the time they were reopened, copper was selling for over 14c. per pound.

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Michigan Reduces Assessment of Local Copper Mines

Because of the "general conditions" affecting the copper producers in Keweenaw and Houghton counties, Mich., F. G. Pardee, state appraiser of mines, recommended a reduction of $4,490,000 in the assessed valuation of the mining properties to a total of $28,429,000. Of this total, $8,465,000 represented the value of the industry in Keweenaw County and $19,964,000 in Houghton County. The reclamation units of Calumet & Hecla Consolidated, which produce the lowest cost copper in the district, were given the highest assessment — $9,300,000. The mining groups to receive the highest assessment were the Ahmeek and Allouez units of Calumet & Hecla, in Keweenaw County, which were assessed at $5,700,000.

Mr. Pardee's statistics show a total of 5,114,207 short tons of ore mined in 1930, and a total of 6,659,207 tons, including reclamation material, treated. Copper output was 169,297,775 lb., which was sold for an average price of 12.5c. a pound. Total costs, per pound of copper produced, exclusive of reclamation copper, were 12.5077c. a pound. This cost includes 2.49c. for general expenses, 7.267c. for mining costs, 2.33c. for treatment costs, and 0.42c. for selling and delivery expense.

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Montana Gold Camps Reflect Interest in Metal

Not since 1905 have so many mining men and prospectors been in the hills of Montana looking for gold, and most of the old gold camps have assumed some form of activity, especially the placer camps, most of which have been idle since pioneer days. In the Virginia City district the California Alder Gulch Corporation is preparing to open two large placer deposits, one to be mined by shaft and tunnel and the other to be worked by drag-line dredging. The company also is preparing to ship high-grade gold quartz from its lode claims a mile south of Virginia City. At this point it is planned to erect a mill to treat the lower-grade ores.

At Pony, Madison County, two properties are working—the Boss Tweed & Clipper and the Atlantic & Pacific. In the gulches from Canyon Ferry to Confederate, in the Helena district, Big Belt Gold Mining and other interests are sinking shafts and running drain tunnels to work some of the richer placer beds that were not worked in the early days. In the Marysville and Bald Butte districts, Lewis & Clark County, claims recently were bonded to financial houses, and in the vicinity of Lincoln, plans have been made to install a dredge on the Tatum placer ground.

At the camp of Norris, Madison County, work is being done on the Stoker group and other claims by Stoker Brothers, Ben H. Jackson, Shelton Hampton, and Senator Whitesides. At the camps of Bannack and Argenta, Beaverhead County, the New Departure and I. B. Mining companies are operating, the latter running a 150-ton fine-grinding cyanide plant. Pat Wall, Kerr Beadle, and associates expect to complete a large dredge in the Gold Creek-Pioneer district, and to the west of Missoula many of the smaller gulches are producing placer gold. One Missoula banker recently stated that his bank is buying more placer gold than at any time during his banking experience. Right now capital is a bit timid in entering any industry, but before the end of this summer indications lead to the belief that several additional gold-mining operations will be started in Montana.

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Construct Lake Geneva Mill

Towagmac Exploration Company has started erecting the 100-ton flotation mill which was designed and materials for which were moved a year ago to the property of the Lake Geneva Mining near Sudbury, Ont. This is a lead-zinc property with some gold and silver recoveries which Towagmac financed through the development stage and under terms of the option was obligated to complete the construction of a mill. The intention is not to operate the mill until metal prices improve. The property has approximately 77,000 short tons of ore in reserve, grade averaging 11.3 per cent zinc, 4.24 per cent lead, 2.33 oz. silver, and 44c. per ton gold. W. G. Hubler, who designed the Amulet mill, has prepared the plans for the Geneva plant.

Provide Publishing Service for Long Technical Articles

The Engineering Societies Library announces the completion of arrangements for the publication of a series of technical treatises to be known as Engineering Societies Monographs. The editorial supervision of this series will be in the hands of a committee consisting of Harrison W. Craver, director of Engineering Societies Library, chairman, and two representatives appointed by each of the Engineering Societies. For many years those who have been interested in the publication of papers, articles, and books devoted to engineering topics have been impressed with the number of important technical manuscripts which have proved too extensive, on the one hand, for publication in the periodicals or proceedings of engineering societies, or in other journals, and of too specialized a character, on the other hand, to justify ordinary commercial publication in book form. No adequate funds or other means of publication have been provided in the engineering field for making these works available to the profession.

Experience has, however, demonstrated the value of proper introduction and sponsorship for such books. Without assuming responsibility for the authors' statements, the engineering societies, through suitable representatives, who have examined a manuscript, will furnish this introduction. Engineering Societies Library will share in any profits made from publishing the Monographs; but the main interest of the societies is service to their members and the public. Engineering Societies Monographs will not be a series in the common use of that term. Physically, they will have similarity, but there will be no regular interval in publication, uniformity in price, nor relation in subjects. What books are printed, and when, will by the nature of the enterprise depend upon what manuscripts are offered, estimation of their usefulness, cost of production in book form, and possibilities of distribution.

The first volume projected for the series is "Plasticity," by Dr. A. Nadai, formerly with the University of Goettingen, now associated with the Research Laboratories of the Westinghouse Electric & Manufacturing Company. It is an adapted and revised translation of Dr. Nadai's well-known treatise in German on this subject.

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Park City Con. Stops Shipping

Shipments of silver ore from the Park City Consolidated property have been suspended because of the low price of silver. This leaves only two mines in the shipping list in the Park City district of Utah. Park City Consolidated had been shipping about 100 tons of ore daily, average grade being nearly 20 oz. of silver to the ton, with small but recoverable quantities of gold, lead, and zinc.

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No L.S.M.I. Meet This Year

The Lake Superior Mining Institute will not meet this year, because of the depression. S. R. Elliott, of Ishpeming, president, conferred with members of the Institute Council concerning the 1931 meeting and the decision reached was not to proceed with plans for a gathering on the Menominee iron range this summer. The meeting will be held in 1932, with Ishpeming as headquarters.

Dorr, Oliver Companies Merge Businesses

J. V. N. Dorr and E. L. Oliver have announced a union of the businesses and assets of The Dorr Company and Oliver United Filters, Inc. This union was brought about on June 1 by the formation of a new company, to be known as Dorr-Oliver Corporation, under the joint management of Messrs. Dorr and Oliver. The corporation will function through two wholly-owned operating units, each of which will retain its present executive and technical staffs. The Dorr Company is engaged in construction of agitation, classification, and sedimentation equipment and Oliver United Filters in construction of filtration equipment. The union is expected to make possible a more complete line of equipment and engineering service than either company could hope to offer individually.

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Supreme Court to Review War Minerals Decisions

On the application of the Secretary of the Interior, the U. S. Supreme Court has consented to review two cases involving claims under the War Minerals Act that were decided against the government in the lower courts. In one suit, Secretary Wilbur asks for the reversal of an order by the Court of Appeals of the District of Columbia allowing the Chestatee Pyrites & Chemical Corporation to submit a claim for interest on money borrowed for the production and preparation of pyrites.

In the other case, the Secretary is appealing from a decision of the lower court permitting Vindicator Consolidated Gold to recover on expenditures made for the purchase of property containing chrome. Counsel for the government in both cases contends that the act of Congress of 1929 allowing the courts to review certain claims under the War Minerals Act does not divest the Secretary of the Interior of all discretion in the administration of the act. The Interior Department feels that it has been lenient in settling claims brought by those who were asked to supply the urgent needs of the nation during the War. The Department does not believe, however, that Congress intended in passing the act of 1929 to pave the way for bringing up disallowed claims totaling $3,000,000 that have been brought under the War Minerals Act, involving purchases of property and payments of interest.

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Tungsten Concentrate Shipped

Tungsten Alloys Corporation, a subsidiary of North American Mines, Inc., Boston, Mass., operating the Guijas mine, 63 miles southwest of Tucson, Ariz., has shipped a 30-ton car of tungsten concentrates, valued at more than $20,000, to Eastern consumers—the largest shipment of tungsten made from Arizona since the War. All concentrates produced at the mill, because of their copper content and other impurities, are first shipped to the magnetic separator of E. C. O'Brien Company, Globe, Ariz. The Guijas mine is probably the largest active producer of tungsten in the United States at present, and a production rate of about 30 tons every ten days is to be maintained. Thomas L. Wells is in charge of operations at Las Guijas.

The gold "strike" made recently at El Tambor, Sinaloa, Mexico, which attracted widespread publicity from the newspapers. This find is described as a fracture in the rock shown in the picture, into which gold has concentrated through erosion of the vein.

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Grant Three Hydraulic Permits

The California Débris Commission has granted permission for hydraulic gold mining at three properties. The Relief Hill property near North Bloomfield, Calif., in charge of Fletcher Hamilton, was given permission to erect restraining barriers, and if these prove satisfactory it will begin operations. Near Stirling City, Butte County, the J. F. Placer property was granted permission to mine 5,000 cu.yd. Engels Copper was given permission to operate its Snowstorm property near Engels.

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Lake Superior Safety Meet

The thirteenth annual mine-safety conference of the Lake Superior mining section of the National Safety Council will be held at the Hotel Duluth, Duluth, Minn., on June 25 and 26. About 250 executives, operators, and safety men from the iron and copper districts are expected to attend, according to F. S. Crawford, chairman of the program committee. The annual banquet, to be held on June 25, will be featured by a play, "The Cousin Jack Dryman," of which W. E. Ball, Oliver Iron Mining, is the director, and by the presentation of awards from the Joseph A. Holmes Safety Association. J. T. Ryan, of the Mine Safety Appliances Company, will be toastmaster at the banquet. Arrangements have been made for prepared discussion of the ten papers to be presented. Fourteen organizations are represented on the committee in charge of the conference.

Arizona Holds "Copper Tariff" Week; Appoints Commission

The conference on the copper depression, held in Phoenix, Ariz., on May 11, has led to further action by Governor G. W. P. Hunt of Arizona. During the week of May 25-30, the State celebrated "Copper Tariff Week," which was capped by a banquet at the Hotel Adams, in Phoenix, on May 28. In addition, the Governor has appointed a Copper Tariff Commission, of five members and 100 advisers, to organize the move for a tariff on imports of the red metal into the United States, and has sent letters to the governors of Montana, Utah, Michigan, Nevada, New Mexico, Tennessee, North Carolina, Pennsylvania, California, and Washington, leading copper-producing states.

The five members of the Copper Tariff Commission include C. W. Van Dyke, who is head of Van Dyke Copper, a company with properties in the Miami district; J. W. Strode, secretary to Governor Hunt; Lem Shattuck, Bisbee banker; Sam Morris, Globe attorney; and John C. Flynn, manager of Shattuck Denn Mining. Mr. Van Dyke is chairman and Mr. Strode, secretary, of the commission. Among the 100 advisers are many of the most prominent mining engineers and mine managers in Arizona, including F. W. Maclennan, of Miami; T. H. O'Brien, of Inspiration; H. A. Clark, of Calumet & Arizona; P. G. Beckett, of Phelps Dodge; and I. H. Barkdoll, of Old Dominion.

Governor George H. Dern of Utah, himself a mining man, has replied to Governor Hunt's letter, stating that for the present he prefers to take a non-committal position on the copper tariff. Because of the fact that an exportable surplus is produced, he is dubious about the benefits that might be derived from a tariff. However, if after the facts are thoroughly investigated, it can be demonstrated that a tariff will protect the domestic industry, he has promised his support.

The final figures on copper production, imports, and exports in the United States in 1930, which were released by the U. S. Bureau of Mines on June 2, show total imports of copper in all forms of 817,154,236 lb. and total exports of 753,114,927 lb. Domestic smelter production was 1,394,389,327 lb., compared with 2,002,863,135 lb. in the preceding year. Refinery production of domestic copper was 1,391,324,205 lb. and total refinery production, including foreign material treated, was 2,157,059,178 lb. Stocks of refined copper increased from 306,000,000 lb. at the end of 1929 to 615,000,000 lb. at the end of 1930. Domestic consumption of new copper was 1,265,016,702 lb., or about 125,000,000 lb. less than domestic refinery production.

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Cut Ashley Ore at 125 Ft.

On the Mining Corporation's Ashley property in Bannockburn Township, Ont., the crosscut at the 125 level showed a considerable amount of free gold and tellurides and gave an assay of about $11 across 7 ft. No further work will be done on the vein until the shaft has reached the 250 level, which should be in June. Much activity is evident throughout the district. Prospectors are numerous, and considerable work is being done on various properties. No new discoveries which appear to be important have been made. Although a promising find is reported from the O'Brien claims, no detailed information is yet available.

Change in Sintering Practice Doubles Plant Capacity

By the simple expedient of screening out the ⅜-in. material from the crude ore fed to its sintering plant and mixing it with the sinter produced, Evergreen Mining, operating at Ironton, Minn., on the Cuyuna Range, has doubled the capacity of its plant, raising it from 1,400 tons of sinter per day to 2,800 tons of so-called "sinter-dried." Oversize from the screens is sent directly to the railroad cars in which the hot sinter is being loaded, and is thus mixed with the latter, the heat of which is sufficient to dry it to the desired moisture content.

The cost of effecting this change was comparatively small. Moreover, the "sinter-dried" product has an analysis and a physical structure that are equally as good as the respective analysis and structure of the sinter heretofore produced. The company, which is independently owned and manages its own sales, now has three products: direct shipping ore, sinter, and sinter-dried.

Another improvement in the plant flowsheet is the practice, recently adopted, of using part of the hot gases from the sintering machines wind box to dry the coke breeze, used for fuel, wherever it is wet, so that it will screen properly and not cut down the capacity of the rod mill used for grinding it.

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Postpone Geological Congress Because of Depression

The Committee on Organization of the Sixteenth International Geological Congress has voted to postpone the meeting of the congress in the United States for a year, to the latter part of June, 1933. Generally adverse economic conditions throughout the world made this postponement desirable.

The following topics for discussion have been tentatively adopted: Measurement of geologic time by any method; batholiths and related intrusives; zonal relations of metalliferous deposits; major division of the Paleozoic system; geomorphogenic processes in arid regions and their resulting forms and products; fossil man and contemporary faunas; and orogenesis.

Routes of excursions have been selected, and work is well advanced on the preparation of the guide-books. A series of excursions, before the congress meets, of from five to twelve days in length will cover the eastern and central states. These will, so far as possible, be arranged to appeal to specialists in various branches of geology. Short excursions in the vicinity of New York will also be scheduled. During the session of the congress, which will last about a week, several short trips will be made to points of interest in the vicinity of Washington. The excursions after the congress will include two in the north-central states—one for glaciologists in Illinois, Iowa, and Wisconsin and the other for mining geologists in the Lake Superior iron and copper districts, each of about ten days' duration—and two transcontinental trips, each of about 35 days.

A circular is now being prepared giving more detailed information. This will be sent to all those who received the first circular and to others interested who request it from the Secretary, Sixteenth International Geological Congress, U. S. Geological Survey, Washington, D. C.

BRIEF NOTES

Bridge River Mine Financed. Toronto and Vancouver interests have acquired control of Bridge River Consolidated Mines, a group of claims carrying lode gold deposits on Cadwallader Creek, in the Bridge River district, British Columbia. It lies to the north of the Pioneer and Lorne groups, both now under intensive development. The terms of the deal provide for immediate development of the property and construction of a mill to cost $100,000.

Burma Corp. Curtails. In April the company mined only 35,079 long tons of ore, which compares with an average of 41,500 tons during the first quarter of 1931, from its Bawdwin mine, near Namtu, Burma. Three crosscuts were completed in ore during the middle of May. The new Meingtha orebody, previously developed only on the Nos. 2 and 6 levels, has been found 40 ft. wide on the No. 4. The grade is 31 per cent lead, 10 per cent zinc, and 25 oz. of silver per ton. On the No. 10 level, the Shan lode was cut 20 ft. south of the Marmion shaft, showing 40 ft. of ore. The Chinaman orebody, cut on the No. 8 level, 1,438 ft. south of the shaft, was found in two sections, with a total width of 34 ft.

Castle-Trethewey Closes. The company, operating a silver property at Bestel, Ont., has closed both mine and mill, after producing about 6,500,000 oz. of silver. Low silver prices are the cause of the shutdown. Although development yielded results in the Capitol shaft area which, two years ago, would have been considered satisfactory, no alternative to closing existed, according to J. P. Bickell, president. One high-grade shoot, found in Capitol ground, produced 150,000 oz. of silver from 2,000 short tons of ore.

Cerro de Potosi Program. Improvements in the reduction plant of Minera Unificada del Cerro de Potosi, controlled by Central Mining & Investment, at Potosi, Bolivia, are nearly completed. Production in 1930 was 1,523 long tons of fine tin and 96,534 oz. of silver, but drop in metal prices resulted in a loss. Unproductive work that had been undertaken to unify the mine layout has been postponed, and production is coming from the higher grade oreshoots so as to obviate operating losses. No further work has been done by Minero-Metalurgica de Bolivia, controlled by the same interests, in preparation for treatment of Potosi tailing dumps, because of the low price of tin. Some research is being continued on plant design, however.

Consolidated Mining Formed. On May 26, approval was given to the merger of the Tuscumbia Mining and Idora Mining, which own adjoining properties in the Coeur d'Alene lead-zinc district of Idaho. The merged company, to be known as Consolidated Mining, has a capitalization of 5,000,000 shares of 10c. par. Stockholders of each of the former companies will receive 1,000,000 shares, and an additional 1,000.000 shares of the 3,000,000 remaining will be used to raise funds for development. C. W. Newton, general manager of Callahan Zinc-Lead, will direct the operations. The first part of the program will be the continuation of Idora tunnel No. 3 into Tuscumbia ground to explore an area, 900 ft. long, from which considerable production was obtained in upper workings. The extension of the Idora vein will be diamond drilled.

Deer Trail Develops Molybdenum. At the annual meeting of Deer Trail Monitor Mines, held recently in Spokane, the statement was made that in driving the main tunnel at the property, southwestern Stevens County, Wash., a molybdenum deposit was encountered. Lateral development proved it to be 350 ft. long. Because of the delay occasioned by exploring this vein, the tunnel has not yet reached its objective, a vein carrying silver. The face of the crosscut at present is reported to look as if it might be near the vein.

Dome Mines Has New Ore. At the mine, near Timmins, Ont., the company has discovered and drifted 100 ft. on a new orebody, 30 ft. wide, and assaying from $5 to $6 a ton in gold, according to a statement made by J. H. Stovel at the annual meeting on May 27. This ore is not related to any previously known. Development has added 100,000 short tons of ore to the reserves since the last estimate was made, at the end of 1930, making a total of 2,000,000 tons in sight. Mill tailing is now carrying about 30c. a ton in gold, indicating an extraction of 95 per cent on $6 ore.

El Cubo Appeals Decision. An appeal to the Mexican Department of Industry, Commerce and Labor has been made by the Compañia Minera "El Cubo," which operates mines in Guanajuato, Mexico, against a ruling of the state labor board that the company immediately reinstate or pay an indemnification of three months' wages to several workers it allegedly dismissed without the required fifteen days' notice. The company contends the dismissals were necessary in view of restricted operations. Employees declare that dismissals were unjustified, as they had assisted the enterprise to save money in operating expenses by accepting a reduced wage.

Idamont Gold Formed. The Bald Butte gold property, near Marysville, Mont., has been acquired by the company, which has been incorporated at Helena by J. A. Blair, of Spokane, Wash.; A. P. Heywood, of Helena, Mont.; and Ralph Mellor, of Marysville. An 80-stamp mill on the property is being remodeled to use the flotation process, under the direction of R. F. Howe, who built the Spring Hill plant of Montana Mines. The power line to the property, from the Missouri River Power hydro-electric plant, near Helena, has been repaired.

Minto Gold Starts. Operation of the new 75-ton cyanide plant of the company, in the Michipicoten district, Ontario, has been started. Average grade of ore is said to be about $11 in gold per ton. Minto Gold has the distinction of being at present the only Ontario gold mine producing outside the Porcupine and Kirkland Lake districts, with the exception of Howey Gold, at Red Lake. Several other properties are expected to be producing by the end of 1931, however. John Knox is manager of the property and expects an annual output of about $300,000 in gold.

Mount Isa Tonnage Rising. According to a company statement, issued May 23, Mount Isa Mines, new lead-zinc pro-

(Continued on page 533)

EXCLUSIVE

CABLES

FROM CORRESPONDENTS IN THE PRINCIPAL MINING CENTERS

Australian Gold Production Increase Continues

Melbourne, May 29.—Production of gold in Australia, stimulated by the increased interest in mining a metal the price of which does not change, by the bonus that the federal government will pay at the end of the year, and by the favorable exchange rate with London, continues to increase. It almost certainly will be more than 500,000 oz. in 1931 and possibly as much as 550,000 or 600,000 oz. The final figures for 1930 show a production of 466,435 oz. This compares with 430,263 oz. in 1929; 457,669 oz. in 1928; and 508,291 oz. in 1927.

. . . . Production of the Federated Malay States for the fiscal year 1929-30 was 29,597 oz. of gold, an increase of about 3,000 oz. The increase results almost entirely from the greater tonnage handled at the Raub Australian Gold property, in Pahang.

. . . . Production of Western Australia in April was 38,893 oz. of gold, compared with 36,652 oz. produced in April, 1930. The increase is largely the result of the first bullion clean-up at Wiluna Gold, which started milling operations in March. At Goongarrie, 90 miles north of Kalgoorlie, 600 oz. of gold has been taken from a pocket of high-grade ore found on the surface.

. . . . The first week of suspended operations at the property of Zinc Corporation started on May 4. This is part of the program of closing down the mine and mill one week out of every four to reduce production without causing unemployment. North Broken Hill will pay no dividend for the quarter ending June 30, and Zinc Corporation has decided to omit the final dividend for 1930, which would be payable at about this time. Following a heavy precipitation, sufficient water is now available for two years of operations at the Broken Hill mines, in New South Wales. At Port Pirie, South Australia, where concentrate is smelter in the plant of Broken Hill lead concentrate is smelted in the plant of Broken Hill Associated Smelters, wages have been reduced to the basic rate of 13s. 2d. per day. Proportionate decreases have been made in all wage and salary payments. A bonus of 6d. per day will be paid to all workers for each increase of £1 per long ton in the price of lead above its present level.

. . . . New Mount Morgan Gold Recoveries is the name of the company that has been formed to acquire a ten-year lease of the famous Mount Morgan copper-gold deposit at Rockhampton, Queensland. The new company has a capital of £80,000 and plans to treat 500 long tons of ore daily at an estimated profit of 4s. 8d. per ton. The ore will be mined by open-pit methods and treated by a process evolved by the American Cyanamid Company after elaborate tests.

. . . . Electrolytic Zinc reports a production of 13,440 long tons of zinc and 59.6 tons of cadmium in the first quarter of 1931 at its Risdon plant, in Tasmania. This is about the same rate as prevailed all through last year, extensions to the plant having been stopped because of the depression in zinc prices. The company employs 807 men at Risdon.

■

President of Malayan Chamber Opposes Tin Quota Scheme

London, June 1.—J. H. Rich, president of the Chamber of Mines of the Federated Malay States, at the annual meeting of the organization said that the new tin export quota scheme, adopted by representatives of the four leading producing countries at The Hague last month, was too hasty and too secret. M. R. Windeatt, supporting Mr. Rich's attitude, said that actual world consumption in 1931 could not exceed 130,000 long tons and probably would be 120.000. Owing to the delay in issuing local assessments, even based on the earlier quota adopted last February, many Malayan mines produced at full capacity during the March-May period. This production is the cause of the recent heavy selling in the Far East (see the issue of May 25, p. 484, for details of the new tin restriction scheme).

. . . . Associated Tin Mines of Nigeria reports production in 1930 of 1,990 long tons of 70 per cent concentrate, compared with 3,062 tons in the preceding year. The average price realized was £99 8s. 2d. per ton and costs were £61, f.o.r. Bukeru. In 1929, costs were £82 8s. 3d., f.o.r. Bukeru. Additional centrifugal pumps have been mounted on pontoons. These will be used for operations in the southern area when power is available from the new development at Kurra Falls.

. . . . At Mount Isa, in northern Queensland, the latest report is that continuous operation of the second mill section is starting immediately and that the first blast furnace will be blown in early this month. (As reported in Brief Notes, p. 531, this issue, the first section of the mill and the sintering plant are already in operation.)

. . . . At Nundydroog Mines, second largest gold producer in the Kolar district, Mysore, India, a fire occurred late in May in a stope on the 4,200 level of the mine and serious loss of life is reported. The fire is still smoldering, but shares in the company have not been greatly affected and there is not expected to be a serious interruption in production. April production of the company was 6,757 oz. of gold from 12,639 long tons of ore.

. . . . Another fire is reported in the Dos Carlos mine of Santa Gertrudis, British-controlled silver producer in the Pachuca district, Hidalgo, Mexico. The fire occurred on the No. 19 level and is now extinguished. Production was interrupted for about ten days. In recent months, the company has been handling only 1,200 short tons of ore daily, although its normal rate is 1,500 tons. Drop in the price of silver, which has made it possible to handle only high-grade ore, is responsible for this lowered tonnage.

. . . . The quarterly report of Rhokana Corporation states that expectations are that the new N'Kana 7,000-ton concentrator will begin operations by Dec. 31, 1931, and that the smelter will be ready soon thereafter. Most of the crushing equipment has been received and installed. Erection of all brick residences included in the original building program at N'Kana has been completed. Also the No. 2 3,000-kw. unit of the power plant and excavation of smelter foundations have been finished. At the N'Changa property, work not essential to the underground program has been stopped. Erection of the permanent power plant should be completed at the end of July.

. . . . Ore extracted from the N'Kana mine in the course of current development has been treated in the pilot mill. The headings are still almost exclusively in the footwall zone, the grade of which is much less than the average of ore reserves. During the quarter, 19,857 short tons of ore, averaging 2.6 per cent copper, was treated, 846 tons of concentrate averaging 52 per cent copper being produced. Recoveries of more than 90 per cent of the total copper content have been obtained. Total underground development at N'Kana during the quarter was 9,892 ft., of which 4,154 ft. was driven in March.

■

Union Minière Treating Panda Tailing in Segregation Unit

Johannesburg, May 26.—The 350-ton pilot unit being erected by Union Minière du Haut-Katanga to test the "segregation" process for treatment of copper ores is operating on tailing dumps at the company's Panda plants. Reference was made to the construction of the unit at the annual meeting of Minerals Separation, which controls the process, in London early this month, but no mention was made of the use to which it was being put. The Panda dumps are said to contain between 4,000,000 and 5,000,000 tons of tailing, containing 4 to 5 per cent copper which has heretofore been unextractable because of its mixed character. The "segregation" process, which involves roasting and flotation, is designed to produce high-grade copper concentrates from mixed oxide-sulphide ores. If the pilot unit is satisfactory, a much larger plant will be installed at Panda.

. . . . A new gold-mining company, known as the Balfour Development Syndicate, has been formed to prospect 200 claims on the Farm Wilgepoort,

southeast of Heidelberg, Transvaal, where Sub Nigel is now making new production records. There is much activity at present in the area northwest of Heidelberg and southeast of the Far East Rand, on the possibility that the Witwatersrand ore-bearing formations may be found to be continuous in that direction.

. . . . The new power plant being built by Globe & Phoenix Gold Mining at its property in the Que Que district, Southern Rhodesia, will be completed within twelve to fifteen months' time. A novel feature will be that two air compressors, with a capacity of 1,710 cu.ft. a minute, will be direct coupled to Crossley-Premier gas engines. The entire haulage system of the property is being electrified, and provision is being made to hoist from a maximum depth of 7,000 ft. Globe & Phoenix is one of the deepest, if not the deepest, of the Rhodesian gold mines, but it is down only a little more than 3,000 ft. vertically below the surface. Equipment to carry the work to 7,000 ft. does not, of course, mean that so great a depth will actually be attained, but it does indicate that the management is prepared to go that deep if the ore persists.

. . . . Considerable staking activity is noted in the neighborhood of the Pongola River, northern Natal. The Farm Klipval has been thrown open to staking.

. . . . A new diamond compact has been promulgated, regulating the quantity of diamonds to be marketed by producers affiliated with the Diamond Syndicate. Under this agreement, the percentages of the total sales that will be allotted to the producing companies follow: De Beers Consolidated, 50.4 per cent; Premier Diamond, 10.6 per cent; New Jagersfontein Mining, 10 per cent; Consolidated Diamond Mines, 25 per cent.

■

Kansanshi Follows Deposits Into Rhokana Ground

London, June 2.—Quarterly report of Rhodesia-Katanga, operating the Kansanshi mine, states that in the quarter ended March 31 development work indicated that the Kansanshi copper deposits extend into adjoining ground held by Rhokana Corporation, under its concession from the British South Africa Company. The two companies are exchanging technical information with regard to the structure of the deposits. Kansanshi is now sinking two shafts, of which the deepest is now down 543 ft. Good borehole results continue to be obtained in various parts of Northern Rhodesia where drills are still being operated.

. . . . Roan Antelope started hoisting ore through its Beatty shaft on May 21. The first unit reached its capacity on May 31. Smelter construction is now 25 per cent completed.

. . . . Mufulira Copper has made a new estimate of reserves in its Mufulira mine. They now stand at 116,000,000 short tons, averaging 4.4 per cent copper, compared with the former estimate of 102,000,000 tons, released a few months ago. No new estimates have been made for the company's Chambishi and Baluba properties.

Canada Revises Tariff Upward; Mining Equipment Unchanged

Toronto, June 2. — Canadian tariff changes, presented in yesterday's budget and effective today, include several revisions of rates on iron and steel products and an increased duty on steel sheets and tables. Feldspar rates were raised slightly, also those on magnesite. The general list of mining machinery and equipment was unchanged, but unclassified machinery from the United States was raised 35 per cent and the duty on all unenumerated items was also raised. The sales tax was increased to 4 per cent on domestic products and to 5 per cent on imports. A tax of 2 per cent was levied, collectible at source, on dividends payable to non-resident shareholders of Canadian companies. This will apply particularly to the mining companies such as International Nickel, Teck-Hughes, Dome Mines, and Noranda, in which Americans have a large shareholding.

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Brief Notes

(Continued from page 531)

ducer in northern Queensland, Australia, was then handling 700 long tons of ore daily in the first section of its concentrator, which started working on May 11. This is about the section's capacity. In addition, the sintering unit of the lead smelter started on May 20. Reserves of ore at the property are about 32,000,000 long tons averaging 8 per cent lead—the largest tonnage developed at any single lead property in the world.

Montana Mines 1930 Output. In 1930, the Spring Hill property of Montana Mines Corporation, near Helena, Mont., produced $225,286 gross, against $163,868 in 1929 and $104,656 in 1928. The company is operating a large body of gold ore located on a lime-quartzite contact. During the year a two-compartment shaft was sunk to a depth of 215 ft. below the main haulage level and nearly 1,000 ft. of diamond drilling was completed. The flotation plant has been handling a little over 200 short tons of ore per day, the concentrates being shipped to the smelter. Research work is now being carried on to extract the precious metals from the concentrates by cyanidation, which it is estimated will save the company about $40,000 a year.

Pioneer Gold's Reserves Up. The company, which produced $350,000 in gold in the year ended March 31 from its mine in the Bridge River area, British Columbia, has ore reserves of $5,000,000. The average grade is about $20 a ton. Of the reserve, according to David Sloan, mine manager, about $500,000 is in broken ore and the remainder is ore in place between the 500 and 1,000 levels. On the 700 level, ore has been proved for a length of 1,632 ft. On the 800 and 900 levels, ore has been proved for 1,400 ft. with the faces of the drifts still in ore. By acquiring the Countess claim, the company now has about 6,500 ft. along the strike of the vein. A new vertical three-compartment shaft is being put down, which will permit an eventual increase in tonnage to 300 tons daily. Completion of the new hydro-electric plant is expected to reduce costs to $5 a ton.

Sons of Gwalia Returning Loan. This company, operating a gold property near Mount Leonora, Western Australia, has returned £10,000 of the £78,000 advanced it by the Western Australian government. This is the first step taken by the company to return the loans, which were made to permit remodeling of the plant. Operations in 1929 were conducted at a slight loss, but an improvement in grade in 1930 made profitable operation possible. The depreciation in Australian currency has also helped the company. Its 1930 output was £162,338 in gold from 155,874 long tons of ore. Sinking of a new main vertical shaft to a depth of 4,000 ft. may be undertaken if the necessary money, about £150,000, can be raised from stockholders. A new shaft would improve ventilation and permit removal of ore at this depth. April output was £14,688 in gold from 12,024 long tons. This does not include exchange premium.

Southern Mining Adds Crushers. Crushing equipment is being installed at the company's iron-ore properties in Butler and Wayne counties, Mo. Four crushers will be installed. One of these will be put in at Taskee and is expected to be operating within a short time. Other units will be at Hendrickson and Williamsville. The location of the fourth crusher has not yet been decided.

Tocopilla Mining Shipments. This company, largest of the Chilean-controlled copper producers in Chile, reports shipment of 8,570 metric tons of concentrate and 17,040 tons of shipping ore in 1930, compared with 7,530 and 24,517, the tonnages in 1929. Shipping ore averages about 16 per cent copper and concentrate about 27 per cent. The drop in the price of copper has evidently made it advisable to treat almost the entire tonnage in the concentrator, and shipments of direct-smelting ore have nearly ceased.

Tom Thumb Unwatered. This property, about 1½ miles north of the Mountain Lion, in the Republic district of Washington, has been unwatered by the Day interests, prominent operators in the Coeur d'Alene district. G. S. Bailey is in charge. Most of the Day properties in Idaho are now closed.

Tungsten Mines to Start. Production is expected to start soon from the company's new 50-ton mill, near Addy, Wash., according to J. P. Reed, president of Tungsten Mines, Inc. The mill will be operated on a one-shift basis at first and will make a concentrate containing more than 75 per cent tungsten. Mr. Reed stated that arrangements have been made for marketing the product in the East.

U.V.X. Ships to France. A shipment of 21 carloads of copper bullion has been made to a fabricating company in Bordeaux, France, from the United Verde Extension smelter at Clemenceau, Ariz. The copper has been shipped by rail to Los Angeles and from there it will go to Bordeaux by a French ship. This is the second shipment of copper to France made by U.V.X. this year.

Western Empire Revamps Mill. The company, which recently reopened the Royal mine, near Hodson, Calif., will increase capacity of its milling plant to 200 short tons daily. Additional flotation and regrinding equipment is on order.

MARKET AND FINANCIAL NEWS

World Zinc Production Reduced in April

Despite the absence of statistics on zinc production from Belgium and Poland, figures available indicate that the world's output during April was between 6,000 and 7,000 tons smaller than in the preceding month. Production for all countries except Belgium and Poland during April amounted to 75,483 tons, against 81,962 tons for the same group in March, a reduction of 6,479 tons.

April production of zinc in the United States showed a drop of 3,191 tons. The trend in production in Germany, France, and Great Britain continues downward, owing chiefly to the difficulty in obtaining cheap ore. The London market for the metal has fallen below £11 per ton, or less than 2½c. per pound. Because of the low prices prevailing, further curtailment is expected. Recent advices from Poland indicate that zinc production in that country has been restricted.

Zinc production of the world during February, March, and April, so far as reported, in short tons, according to the American Bureau of Metal Statistics, was as follows:

	Feb.	Mar.	Apr.
United States	29,562	32,328	29,137
Mexico	3,238	3,275	3,384
Canada	10,169	11,622	11,280
Belgium	(d)	(d)	(d)
France	5,756	6,350	6,105
Germany (a)	5,333	4,884	3,944
Great Britain	2,881	3,218	2,192
Italy	1,832	1,532	1,433
Netherlands	1,785	2,056	1,924
Poland (b)	15,387	15,577	(d)
Spain	874	963	947
Australia	4,641	5,139	5,006
Rhodesia	1,381	1,495	1,131
Elsewhere (c)	8,100	9,100	9,000
Totals	90,939	97,539	.....

(a) Includes zinc dust, which amounts to about 300 tons per month. (b) Includes zinc dust. (c) Partly estimated. (d) Not reported.

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Trading in Silver Futures

Members of the National Metal Exchange, New York, on May 25 unanimously approved amendments to the bylaws to provide for trading in silver futures, which will start on June 15.

Exporters and importers dealing with countries that have a silver standard will be enabled by the establishment of the silver futures market to hedge their silver commitments, according to Ivan Reitler, president of the Exchange.

E.&M.J. Weighted Index of Non-Ferrous Metal Prices

100 Is Composite for 1922-3-4

1920	130.92
1921	80.80
1922	93.94
1923	103.43
1924	102.63
1925	111.74
1926	107.74
1927	97.54
1928	99.78
1929	110.33
1930	82.87

	1929	1930	1931
January	106.86	102.94	67.62
February	110.37	102.28	65.90
March	122.71	99.93	68.03
April	116.36	93.24	64.45
May	110.03	83.41	59.81
June	109.66	78.57	.....
July	109.58	74.58	.....
August	109.81	74.41	.....
September	109.29	73.42	.....
October	108.52	69.63	.....
November	106.09	71.39	.....
December	104.75	70.65	.....

■

McIntyre Porcupine Profit Was Higher in 1930-31

During the year ended March 31, 1931, McIntyre Porcupine Mines, Ontario gold producer, made a net profit, before depreciation, of $2,134,377. This compares with $2,072,300 earned in the year ended March 31, 1930. The increase was the result of the greater production — $4,633,324, compared with $4,457,001—and of a slightly greater non-operating revenue. The operating profit in 1930-31 was $2,086,049.

At March 31, 1931, the company's surplus stood at $4,653,623, compared with $4,158,140 at the beginning of the year. In addition to adding nearly $500,000 to surplus, the company transferred $400,000 to its general-reserve account. The balance sheet shows total assets of $13,523,999 on March 31, of which $3,464,508 was current assets and $864,993 was investments in subsidiary companies. Net additions during the year to the company's plant and equipment was $1,273,645, spent largely for construction of the new 2,000-ton mill. Current liabilities on March 31 were $572,952.

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Financial Notes

WALKER MINING, California copper producer, reports a net income of $2,899 in the first quarter of 1931, after depreciation charges. Operating profit on sales of ore and concentrate of $308,842 was $21,584. The company sold 7,003 dry tons during the quarter.

NORTH LILY MINING, Utah lead producer, reports an income of $30,922 in the first quarter of 1931, after taxes but before depreciation. Operating profit on ore sales of $100,839 was $27,963. The company sold 6,285 tons of ore.

FRESNILLO MINES, Mexican lead-silver-zinc producer, reports gross revenue, after allowing for development, but before depletion or depreciation, of $3,655 in the first quarter of 1931. The value of production from 256,546 tons of ore was $628,889.

MEXICAN CORPORATION, Mexican copper-zinc producer, reports a loss $7,498 before depreciation or depletion in the first quarter of 1931. Operating loss, before miscellaneous profit or development charges, was $16,228 on a production of $151,518 in copper and zinc concentrate, representing the treatment of 17,179 tons of ore.

Mining Company Dividends for May, 1931

Companies in the United States	Situation	Per Share	Total Disbursements
Alaska Juneau, g	Alaska	$0.10 Q	$144,600
American Smelting & Refining	Various	1.00 Q	1,829,940
Anaconda Copper, c, z, l, s	Various	0.37½Q	3,321,882
Bunker Hill & Sullivan, l, s	Idaho	0.25 M	81,750
Homestake Mining, g	S. Dakota	0.50 M	125,580
Mohawk Mining, c	Michigan	0.25 Q	28,750
National Lead, pfd., "B"	Various	1.50 Q	154,913
New Jersey Zinc	Various	0.50 Q	981,632
United Verde Extension, c	Arizona	0.50 Q	525,000
Companies in Other Countries			
Cerro de Pasco, c, s	Peru	0.37½Q	424,065
Hollinger Consolidated Gold	Canada	0.05 M	246,000
Teck-Hughes, g	Canada	0.15 Q	713,574
Total			$8,577,686

c, copper: z, zinc: l, lead: s, silver: g, gold: n, nickel: Q, quarterly: M, monthly.

U. S. Smelter Output of Copper Down 30 per Cent in 1930

The smelter output of copper from ores of domestic origin in 1930 amounted to 1,394,389,327 lb., a drop of 30 per cent compared with the output in 1929, according to the U. S. Bureau of Mines. Refinery production from domestic and foreign sources totaled 2,157,059,178 lb., 21 per cent less than the 2,740,112,376 lb. recorded for 1929. Imports of unmanufactured copper dropped 16 per cent and exports of metallic copper, 24 per cent. Stocks of refined copper at the end of 1930 were more than twice those at the end of 1929. Stocks of blister at smelters, in transit to refineries, and stocks of blister and unfinished materials at refineries, showed a drop of 10 per cent in 1930, but total smelter and refinery stocks were about 32 per cent higher at the end of 1930 than at the end of 1929. Estimated withdrawals of new copper from total supply on domestic account were 29 per cent lower than in 1929.

The smelter production of primary copper from domestic sources during 1930 amounted to 1,394,389,327 lb., a decrease of approximately 30 per cent. The value of smelter production decreased approximately 49 per cent in 1930. The average price of 2,477,540,000 lb. of copper delivered during the year, as reported to the Bureau of Mines by selling agencies, was 13c. a pound.

In the following table the production is apportioned to the states in which the copper was mined. The figures represent the content of fine copper in the blister produced, the smelter output of ingot, and anode copper from Michigan.

Copper Produced from Domestic Ores

(Smelter output, in pounds)

State	1929	1930
Alaska	39,867,940	36,380,038
Arizona	829,206,475	570,897,080
California	33,084,232	26,262,447
Colorado	10,519,784	12,943,857
Idaho	6,267,487	2,713,681
Michigan	185,300,917	142,985,522
Missouri	1,880	2,198
Montana	299,894,853	198,795,883
Nevada	138,990,247	87,475,019
New Mexico	100,165,206	74,187,966
North Carolina	(a)	(a)
Oregon	739,151	229,753
Pennsylvania	3,581,393	3,061,174
Tennessee	(a)	(a)
Texas	393,740	165,731
Utah	325,965,289	205,769,698
Vermont	752,200	(a)
Washington	1,569,260	1,404,893
Wyoming	4,305	29,356
Undistributed	26,558,776	31,085,031
	2,002,863,135	1,394,389,327

(a) Included under undistributed. Bureau not at liberty to publish.

■

GREAT NORTHERN IRON ORE PROPERTIES, which leases its holdings to iron-mining companies, reports gross receipts of $3,399,555 in 1930, compared with $4,952,103 in 1929. The profit in 1930 was $3,375,761, compared with $4,876,473 in 1929.

United States Copper Statistics, 1929 and 1930

(U. S. Bureau of Mines)

	1929	1930
Production of copper		
Smelter output, pounds	2,002,863,135	1,394,389,327
Mine production, pounds	1,995,110,398	(a)
Refinery production of new copper		
Electrolytic, pounds	1,785,754,654	1,228,416,733
Lake, pounds	185,300,917	142,985,522
Casting, pounds	11,676,718	19,821,950
Total domestic, pounds	1,982,732,289	1,391,224,205
Total domestic and foreign, pounds	2,740,112,376	2,157,059,178
Total new and old copper, pounds	3,993,000,000	(a)
Ore produced		
Copper ore, old tailing, short tons	68,421,853	(a)
Average yield of copper, per cent	1.41	(a)
Copper-lead and copper-zinc ores, short tons	259,126	(a)
Average price per pound, cents	17.6	13.0
Imports (unmanufactured), pounds	974,312,201	817,154,236
Exports of metallic copper, pounds (b)	992,895,119	753,114,927
Withdrawn from total supply on domestic account		
Total new copper, pounds	1,778,585,415	1,265,016,702
Total new and old copper, pounds	3,032,000,000	(a)
Stocks of refined copper, pounds (c)	306,000,000	615,000,000
Stocks of blister and materials in solution (c)	500,000,000	450,000,000
Value of smelter production from domestic ores	$352,504,000	$181,271,000

(a) Figures not yet available. (b) Total exports of copper, exclusive of ore, concentrates, composition metal, and unrefined material. (c) At the end of the year.

German Copper Buyers Favor Outside Producers

DR. JAMES RUBINFELD
BERLIN

American Metal is about to establish a copper-sales agency in Berlin, whereas in recent years its London agency has handled this business with Germany through Copper Exporters, Inc., at Brussels. Much comment has been aroused by this move of American Metal, particularly since the drop in the local consumption of copper has served to make Germany almost independent of Copper Exporters. Some of the largest consumers, such as Hirsch Kupfer & Messingwerke, are buying copper almost entirely outside of the Copper Exporters' organization. Production of Norddeutsche Affinerie (Metallgesellschaft's big refinery), Mansfeld, the Niederschoneweide smelter of the Hirsch-Schoyer interests, and of the new Wilhelmsburg refinery, is estimated to be sufficient to meet 60 per cent of German consumption.

The Wilhelmsburg refinery, in which Brandeis, Goldschmidt, of London, has a large interest, is reported to be underbidding the offerings of the American producers on the Berlin, Hamburg, Cologne, and Frankfort markets. Consumption has dropped off, notably in the transportation and communication fields. Cable, car, and telephone makers feel that they have suffered as a result of the "topsy-turvy price policy" of Brussels, which they claim does not permit of hedging. Because no time options on electrolytic copper are permitted, users continue to maintain a hand-to-mouth buying policy.

The comparative firmness of the aluminum market is considered surprising, in view of the wide spread that is now existent between its price and that of copper. One of the chief factors is said to be purchases by Russia on liberal credit terms. The German industry is working only at a third of capacity. Russian consumption is evidently to be an increasingly important factor in the metal industries.

German metal consumption is about 20 to 30 per cent below the level of the spring of 1930, and 1930 was a bad year. The zinc producers are in a particularly poor condition, and reports are heard that the few smelters still running may close. Stolberg Zinc has shut down the Birkengang and Nievenheim smelters. In Polish Upper Silesia, further curtailment is reported at the Hohenlohe mines. One of the chief factors in the condition of the German smelters is the demand for what is called a "time-price" guarantee by ore producers. The Metallwerke Unterweser smelter has refused to accede to these demands and has been forced to close. By installation of new equipment last year, this plant's 1930 output was actually higher than in 1929. Stolberg Zinc also reported increased production of silver, lead, zinc, and quicksilver in 1930. Demands for a tariff on imports of slab zinc into Germany are again being heard.

In its annual report, Vieille Montagne, leading Belgian zinc producer, suggests that despite the apparent failure of the two most recent zinc producers' conferences, at Paris and Ostend, some benefit has been derived in that production trends have been more accurately analyzed. No dividend has been declared, and the company is protesting against increased Canadian and Mexican output. It claims to be restricting its own production by 29 per cent to an annual basis of 92,000 metric tons. Capacity is 130,000 tons. However, 1930 output was actually 112,000 tons, or about 8 per cent of the world total.

In 1930, the Niederschoneweide plant produced 10.054 metric tons of refined copper and 12,015 tons of cathodes, or about double the 1928 output. Use of scrap of low-copper content at this plant has fallen off because of the comparatively high freight rates.

Copper in Good Demand as Price Drops to 8c.—Lead, Zinc, and Tin Quiet

New York, June 4, 1931.—Copper was the feature of the non-ferrous metal market, free offerings by both custom smelters and producers driving the price down to a new all-time low of 8c. delivered Connecticut. Tin declined to a new low for the present century, the price touching 22.35c. yesterday; in 1899 the price dropped slightly below 20c. Lead, silver, and zinc were substantially unchanged in price, though demand was dull. Among the minor metals, antimony is slightly lower, and the foreign quicksilver cartel cut its price £5 per flask, to £16½, equivalent to the price ruling in the New York market. Continued declines in metal prices are in line with lower prices for other commodities and the recent pronounced weakness in the stock market.

Copper Sales Improve

The market for copper declined a full cent a pound in the last two weeks, to 8c., delivered Connecticut, the lowest price in the history of the industry. Custom copper was not entirely, or even principally, responsible for the pressure to sell, some small producers evidently being anxious to raise cash. Canadian copper was offered quite freely. The bargain prices naturally stimulated business, and in the last fortnight about 36,000 tons of copper were sold to domestic consumers. Most of the business was booked at 8½c. and under. Sellers, in a number of instances, included copper for fourth-quarter delivery. Consumers seem well supplied with copper for current requirements, their orders having shown little or no improvement, and are merely buying for forward shipment because the metal is cheap.

Foreign consumers have shown little interest except when the export price is in line with the domestic market. Copper Exporters, Inc., reduced the price from 9.025c. to 8.775c., c.i.f. basis, on June 2, and to 8.525c. on June 4. Export sales during the month of May amounted to about 22,300 long tons.

Officials of the Katanga group have returned to Belgium. No general policy of further curtailment is in sight, and evidently the price is being allowed to drop to the point where further restriction or cessation of output will be forced for individual producers with high costs. May statistics are almost certain to be unfavorable, with an increase in refined stocks greater than was witnessed at the end of April indicated.

Zinc Weakens

In the absence of demand from consumers, the market for zinc again eased off. Galvanizers and sheet mills showed no interest in the metal, even at lower prices, and toward the close the market was a wholly nominal affair. On prompt and near-by zinc, Prime Western, there were offerings on the basis of 3.20c. per pound, a new low for the movement. Production is still regarded as too high for the good of the industry. Zinc concentrate was a shade firmer in the Tri-State district on moderate offerings. Some business went through in Prime, basis 60 per cent zinc, at $21 per ton, against the recent low of $20. The market settled at $20 to $21 per ton. None of the reserve is subject to forced sale, according to reports from Joplin, being held by a few companies well able to carry it.

Lead Quiet

The price of lead held at 3.75c., New York, the contract basis of the American Smelting & Refining Company, and at 3.60c., St. Louis, throughout the period. Except for a fair demand from corroders and battery makers, the buying was of modest proportions. The weakness in copper undoubtedly had an influence on buyers. Early in the period most sellers of lead regarded the market as steady, but shortly before the close sentiment was rather mixed.

Statistically, the lead situation appears to be slowly righting itself. Though May shipments of virgin lead may not exceed 32,000 tons, a poor showing, production for the month, according to operators in lead, was even smaller than in April. In other words, the market is approaching the point, unless consumption should suddenly drop further, where a balance between production and consumption is not far off. Total sales for May amounted to about 35,000 tons.

The domestic market is well below London parity. Three-months' lead in London, June 3, was quoted at £10 15s., equal to about 4.43c., New York, duty included.

Tin Stocks Increase

The tin statistics for May showed an increase in the world's visible supply of 2,769 long tons. The visible supply at the end of May was estimated at 51,231 long tons, against 48,462 long tons in April, and 39,771 long tons in May, 1930. This news had a depressing influence on the market, yet, on liberal support from the London tin group, prices did not suffer much. Buying of tin by consumers has been rather dull. The proposal further to curtail output 20,000 tons yearly, effective June 1, has been ratified. Traders feel that the market might have steadied on this announcement had the other metals, chiefly copper, been able to hold their own. Straits tin in New York showed a net decline of ½c. in the last week.

Average Metal Prices for May, 1931

COPPER:	
Electrolytic, refinery	8.665
London Standard Spot	38.897
London Electrolytic, Bid	42.175
LEAD:	
New York	3.818
St. Louis	3.651
London Spot	11.491
London Forward	11.778
SILVER:	
New York	27.650
London	12.858
Sterling Exchange	486.188
ZINC:	
St. Louis	3.306
London Spot	10.484
London Forward	10.875
TIN:	
Straits	23.221
London Standard Spot	104.331
QUICKSILVER	101.140
ANTIMONY	6.524
PLATINUM, Refined	24.980
CADMIUM	55.000
ALUMINUM, 99 Per Cent Plus	23.300

Silver Unsettled

Little change has occurred in the tendency of the silver market during the past fortnight. The small daily offerings have been purchased for China account, but as there has been no keen competitive buying, prices have been governed largely by China parities.

Other Metals

Quotations cover wholesale lots, f.o.b. New York, unless otherwise specified. London prices are according to latest mail advices.

ALUMINUM—Per lb., delivered, Alcoa commercial and mill ingot, 99 and 98 per cent, 23.30c.; Alcoa No. 12 alloy, 22c.; metallurgical ingot, 94 per cent plus, 23.30c.; 98@99 per cent, 22.90c. London, £85, less 2 per cent, per long ton, for 98 per cent ingots and bars.

ANTIMONY—Per lb., duty paid: Chinese, spot, 6.30c.; futures, 6.25c. Demand remains dull and prices closed 15 points lower than two weeks ago. Cookson's "C" grade, spot, 12c. "C.M.C." grade, 99.9 per cent, spot, 11c.

BISMUTH—Per lb., $1.50. London, 5s. 6d. for lots of 5 cwt. or more.

CADMIUM—Per lb., 55c. London, 1s. 9½d.@1s. 10½d.

IRIDIUM — Per oz., $105 for 98@99 per cent sponge and powder. London, £24.

NICKEL—Per lb. electrolytic cathodes, 35c.; shot and ingot made from remelted electro, 36c., for single lots of spot metal. London, per long ton, £170 @£175, as to quantity.

PALLADIUM — Per oz., $19@$21. London, £3 12s. 6d.

PLATINUM—Per oz., official price of leading interest $27.50. Cash trans-

Daily Prices of Metals

May / June	Electrolytic Copper	Straits Tin	Lead		Zinc
	Refinery	New York	New York	St. Louis	St. Louis
21	8.325	23.15	3.75	3.60	3.35
22	8.275@8.525	23.35	3.75	3.60	3.325
23	8.525@8.775	23.15	3.75	3.60	3.30
25	8.525	23.125	3.75	3.60	3.30
26	8.525	22.75@23.00	3.75	3.60	3.30
27	8.35	22.85@23.00	3.75	3.60	3.25
Av'ge	8.463	23.096	3.750	3.600	3.304
28	8.275	22.50	3.75	3.60	3.25
29	8.275	22.625@22.75	3.75	3.60	3.25
30			Holiday		
1	8.15	22.40@22.45	3.75	3.60	3.25
2	7.85	22.40	3.75	3.60	3.25
3	7.775	22.35@22.40	3.75	3.60	3.20@3.25
Av'ge	8.065	22.478	3.750	3.600	3.245

Average prices for calendar week ended May 23, 1931, are: Copper, 8.575c.; Straits tin, 23.425c.; New York lead, 3.750c.; St. Louis lead, 3.600 c.; Zinc, 3.338c.; Silver, 27.250c.

Average prices for calendar week ended May 30, 1931, are: Copper, 8.390c.; Straits tin, 22.823c.; New York lead, 3.750c.; St. Louis lead, 3,600c.; Zinc, 3.270c.; Silver, 26.550c.

The above quotations are our appraisal of the major markets for domestic consumption based on sales reported by producers and agencies. They are reduced to the basis of cash, New York or St. Louis, as noted. All prices are in cents per pound.

Copper, lead, and zinc quotations are based on sales for both prompt and future deliveries; tin quotations are for prompt delivery only.

In the trade, copper prices are quoted on a delivered basis; that is, delivered at consumer's plant. As delivery and interest charges vary with the destination, the figures shown above are net prices of refineries on the Atlantic seaboard. Delivered prices in New England average 0.225c. per pound above those quoted.

Quotations for copper are for the ordinary forms of wirebars and ingot bars. For ingots an extra 0.05c. per pound is charged; for slabs, 0.075c.; and for cakes, 0.125c. up depending on weight. Cathodes are sold at a discount of 0.125c. per pound.

Quotations for zinc are for ordinary Prime Western brands. Zinc in New York is now quoted at 0.35c. per pound above St. Louis, this being the freight differential. The contract price for High-Grade zinc delivered in the East and Middle West is 1c. above the St. Louis price for Prime Western.

Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

Silver, Gold, and Sterling Exchange

May	Sterling Exchange "Checks"	Silver		Gold, London	May June	Sterling Exchange "Checks"	Silver		Gold, London
		New York	London				New York	London	
21	4.86 1/4	27 1/2	12 13/16	84s 9 3/4d	28	4.86 3/16	26 7/8	12 5/16	84s 11d.
22	4.86 5/16	27 1/8	12 1/8	84s 9 3/4d	29	4.86 1/4	26	12 1/8	84s 9 3/4d
23	4.86 5/16	26 1/2	12 5/16	.....	30	Holiday	Holiday	12 3/16	.....
25	4.86 3/8	26 3/8	Holiday	Holiday	1	4.86 5/16	26 3/8	12 1/4	84s 9 3/4d.
26	4.86 5/16	26 3/4	12 1/2	84s 11d	2	4.86 7/16	26 1/2	12 3/8	84s 10 1/2d
27	4.86 3/16	26 1/2	12 3/8	84s 9 3/4d	3	4.86 1/2	26 3/8	12 5/16	84s 10 7/8d

Average for week ended May 27: Silver, 26.833c.; Sterling Exchange, $4.86292.

Average for week ended June 3: Silver, 26.425c.; Sterling Exchange, $4.86338.

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of silver, 999 fine. London silver quotations are in pence per troy ounce of bar silver, basis of 925 fine. Sterling quotations represent the demand market in the forenoon. Cables command five-thirty-seconds of a cent premium.

London

May / June	Copper Standard		Electrolytic (Bid)	Tin		Lead		Zinc	
	Spot	3 M		Spot	3 M	Spot	3M	Spot	3 M
21	37 13/16	38 7/16	41 1/2	103 1/4	104 3/8	11 1/2	11 13/16	10 3/8	10 3/4
22	37 5/16	38	41	104 3/8	106	11 7/16	11 3/4	10 7/16	10 1/2 16
25					Holiday				
26	37 13/16	38 7/16	41	102 1/2	103 1/2	11 3/8	11 11/16	10 3/8	10 7/8
27	37 3/16	37 7/8	40 1/2	102 1/2	104	11 5/16	11 5/8	10 7/16	10 11/16
28	36 13/16	37 1/2	39 1/2	101 3/8	102 1/4	11	11 1/4	10 5/16	10 1/2
29	36 3/8	36 13/16	39 1/2	100 3/4	102 1/4	10 3/8	10 3/4	10	10 1/4
1	35 13/16	36 1/2	40	100 3/4	102 1/2	10 13/16	11 1/4	9 15/16	10 1/2
2	35 7/16	35 3/4	39	100 3/4	102	10 11/16	11 1/16	9 13/16	10 5/16
3	34 7/8	35 1/16	39	100 3/8	102	10 3/8	10 3/4	9 11/16	10 1/4

Prices for lead and zinc are the official price for the morning session of the London Metal Exchange; prices for copper and tin are the official closing buyers' prices. All are in pounds sterling per long ton (2,240 lb.).

actions between dealers several dollars less. London quotes £5 2s. 6d. to £5 7s. 6d.

QUICKSILVER—Per 76-lb. flask, $100. Offerings increased in some quarters and the market was unsettled on reports from London to the effect that the European cartel lowered its official price from £21 7s. 6d. to £16 15s. The revised price is equal to about $102, duty paid, New York.

Chromium, Cobalt, Magnesium, Manganese, Molybdenum, Osmium, Radium, Rhodium, Ruthenium, Selenium, Silicon, Tantalum, Tellurium, Thallium, and Tungsten are unchanged from prices given in the May 25 issue.

Metallic Ores

Prices in tons of 2,000 lb., or in "Units" of 20 lb., unless otherwise stated.

CHROME ORE—Per long ton, c.i.f. Atlantic ports, Indian ores, $19 for 46@48 per cent Cr_2O_3 ore, and $23.50@$24 for 50@51 per cent ore. London, 75s. for 48 per cent Rhodesian, and 77s. 6d.@ 87s. 6d. for Indian and New Caledonian, according to quality.

IRON ORE—Per long ton unit, foreign ores alongside docks Atlantic ports, cargo lots, North African and Swedish, low phosphorus, 9@9½c. Spanish and North African basic, 50 to 60 per cent, 9c. Other prices in May 25 issue.

MANGANESE ORE—Per long ton unit of Mn, c.i.f. North Atlantic ports, cargo lots, exclusive of duty of 1c. per lb. of Mn contained: Indian, 48 to 50 per cent, 26@27c., nominal; South African, 52 to 54 per cent, 25@26c.; 50 to 52 per cent, 24@25c.; 44 to 46 per cent, 23½c. Caucasian, 52@55 per cent, 25@26c.

Chemical grades, per ton, in carload lots, powdered, coarse, or fine, $60, f.o.b. mines or Atlantic ports.

TUNGSTEN ORE—Per unit of WO_3, New York: Chinese wolframite, duty paid, $11.25. Bolivian scheelite, $11.50; domestic scheelite, $12. Nominal.

Antimony, Beryllium, Molybdenum, Tantalum, Tin, Titanium, Vanadium, and Zircon ores are unchanged from prices given in the May 25 issue.

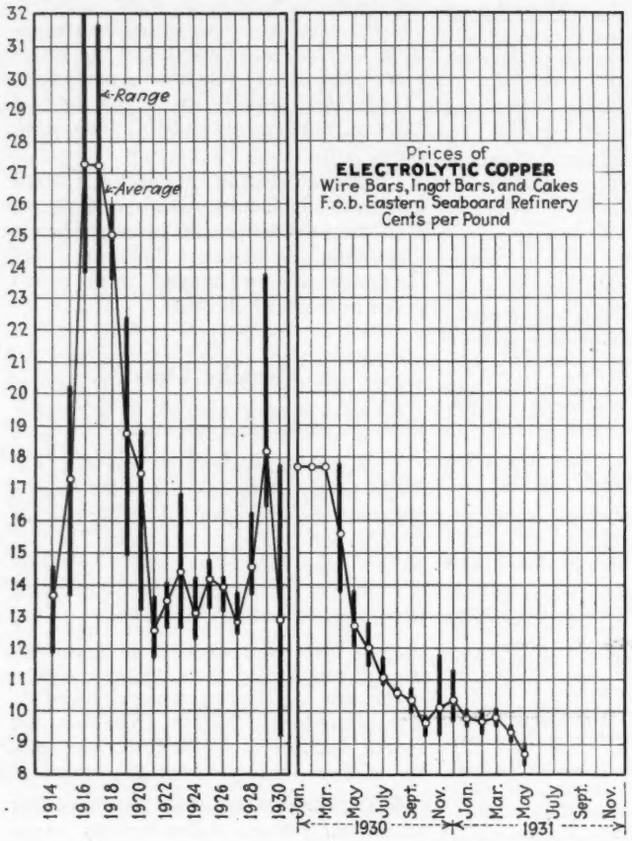
Alloys

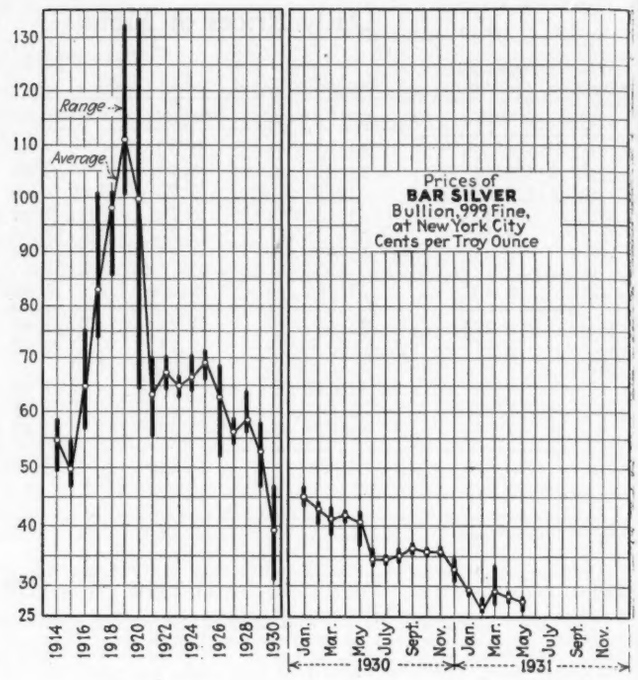
FERROCHROME—Per lb. of contained chromium, 4 to 6 per cent carbon, 65 to 70 per cent chromium, 11c., delivered, on contracts; spot, 11½c. Containing 2 per cent carbon, 67 to 72 per cent chromium, 17½c.; maximum 0.10 per cent carbon, 26c.

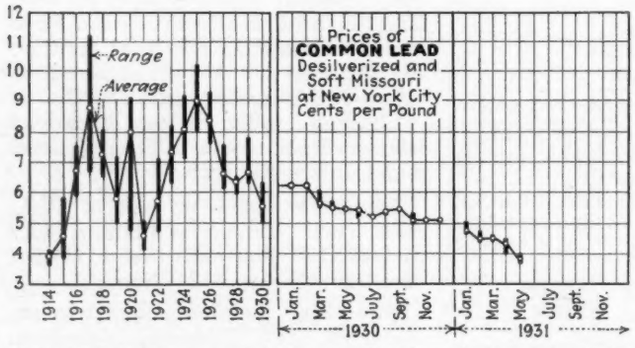
FERROMANGANESE — Per gross ton, furnace; domestic and foreign, 78@82 per cent, $80@$85, contracts, depending on quantity. Spiegeleisen, 19@21 per cent, $30 for spot carloads.

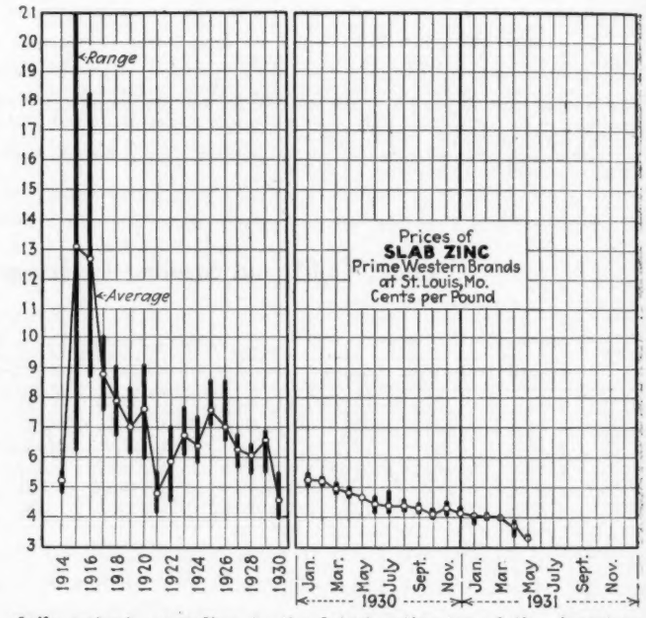
FERROMOLYBDENUM—Per lb. of Mo, f.o.b. shipping point, 50@60 per cent Mo, $1.

Metal Price and Production Curves

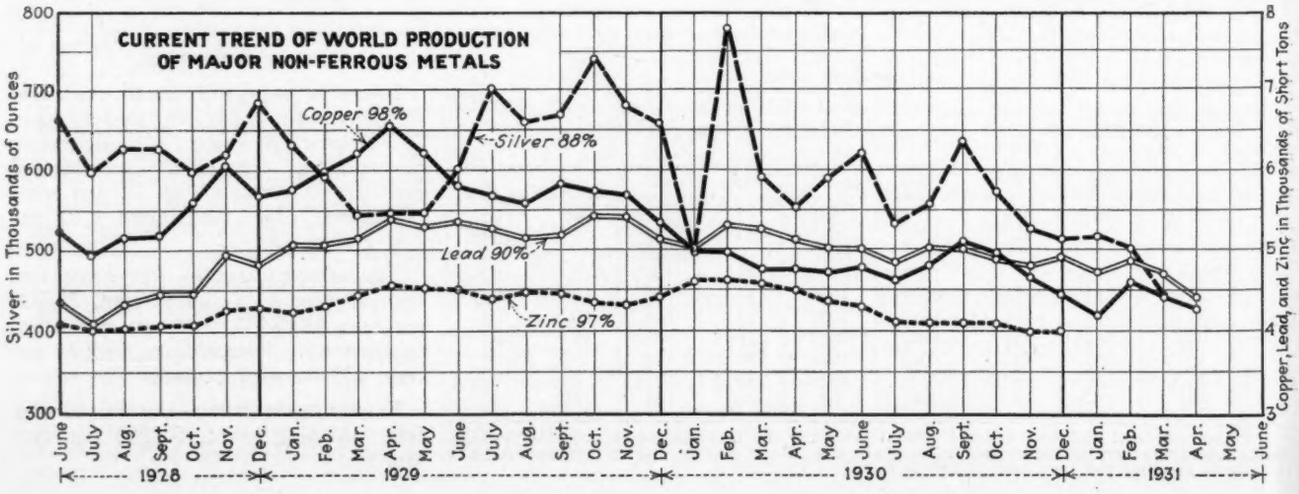








The curves below are not to be considered as permanent records of production. They show merely the current trend in terms of daily output, according to the latest estimates of the American Bureau of Metal Statistics.


CURRENT TREND OF WORLD PRODUCTION
OF MAJOR NON-FERROUS METALS
Copper 98%
Silver 88%
Lead 90%
Zinc 97%
Silver in Thousands of Ounces
Copper, Lead, and Zinc in Thousands of Short Tons
June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June
1928
1929
1930
1931

Metal Statistics

Monthly Average Prices of Metals

(See daily price table for basis of quoting)

Silver

	New York		London Spot		Sterling Exchange	
	1930	1931	1930	1931	1930	1931
January	45.000	29.423	20.896	13.810	486.447	485.260
February	43.193	26.773	20.008	12.432	485.784	485.551
March	41.654	29.192	19.298	13.524	485.933	485.596
April	42.428	28.279	19.554	13.120	486.019	485.764
May	40.736	27.650	18.850	12.858	485.724	486.188
June	34.595	.....	16.049	.....	485.625	.....
July	34.346	.....	15.928	.....	486.300	.....
August	35.192	.....	16.283	.....	486.839	.....
September	36.315	.....	16.738	.....	485.888	.....
October	35.846	.....	16.563	.....	485.719	.....
November	35.908	.....	16.625	.....	485.454	.....
December	32.635	.....	15.201	.....	485.413	.....
Year	38.154	.....	17.666	.....	485.929	.....

New York quotations, cents per ounce troy, 999 fine. London, pence per ounce, sterling silver, 925 fine. Sterling exchange in cents.

Copper

	F.O.B. Refinery		London Spot			
	Electrolytic		Standard		Electrolytic	
	1930	1931	1930	1931	1930	1931
January	17.775	9.838	71.469	44.938	83.250	47.524
February	17.775	9.724	71.419	45.372	83.500	47.950
March	17.775	9.854	69.202	44.818	83.405	47.699
April	15.621	9.392	62.075	42.694	74.338	45.375
May	12.756	8.665	53.159	38.897	59.545	42.175
June	12.049	.....	50.003	.....	56.750	.....
July	11.023	.....	48.277	.....	52.522	.....
August	10.693	.....	47.525	.....	50.725	.....
September	10.310	.....	46.264	.....	49.500	.....
October	9.597	.....	43.030	.....	45.772	.....
November	10.113	.....	46.134	.....	48.963	.....
December	10.300	.....	46.771	.....	50.065	.....
Year	12.982	.....	54.611	.....	61.528	.....

New York quotations, cents per pound London, pounds sterling per long ton

Lead

	New York		St. Louis		London			
	1930	1931	1930	1931	1930 Spot	1930 3 Mos.	1931 Spot	1931 3 Mos.
January	6.250	4.802	6.100	4.604	21.545	21.571	13.872	13.905
February	6.236	4.552	6.086	4.340	21.188	21.097	13.444	13.550
March	5.662	4.527	5.542	4.276	18.807	18.940	13.128	13.355
April	5.537	4.412	5.428	4.164	18.319	18.363	12.375	12.606
May	5.523	3.818	5.408	3.651	17.795	17.861	11.491	11.778
June	5.410	.....	5.310	.....	17.941	17.994	.....	.....
July	5.250	.....	5.149	.....	18.160	18.063	.....	.....
August	5.488	.....	5.340	.....	18.294	18.178	.....	.....
September	5.500	.....	5.348	.....	17.909	17.798	.....	.....
October	5.151	.....	4.999	.....	15.747	15 674	.....	.....
November	5.100	.....	4.950	.....	15.934	15.931	.....	.....
December	5.100	.....	4.950	.....	15.283	15.292	.....	.....
Year	5.517	.....	5.384	.....	18.077	18.064	.....	.....

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Tin and Cadmium

	New York		London		Cadmium
	1930	1931	1930	1931	1931
	Straits		Spot		
January	38.851	26.137	175.466	115.798	67.115
February	38.676	26.315	173.750	117.919	55.000
March	36.798	27.065	164.851	121.852	55.000
April	36.077	25.222	162.638	112 775	55.000
May	32.108	23.221	144.818	104.331	55.000
June	30.336	.....	136.300	.....	.....
July	29.822	.....	134.511	.....	.....
August	30.044	.....	134.988	.....	.....
September	29.647	.....	132.631	.....	.....
October	26.802	.....	117.451	.....	.....
November	25.904	.....	113.519	.....	.....
December	25.262	.....	111.560	.....	.....
Year	31.694	.....	141.873	.....	.....

New York quotations, cents per pound. London, pounds sterling per long ton.

Zinc

	St Louis		London			
	1930	1931	1930 Spot	1930 3 Mos.	1931 Spot	1931 3 Mos.
January	5.229	4.035	19.634	20.241	12.747	13.113
February	5.180	4.012	19.209	19.778	12.303	12.694
March	4.934	4.002	18.304	18.810	12.190	12.676
April	4.843	3.717	17.819	18.378	11.353	11.838
May	4.641	3.306	16.639	17.330	10.484	10.875
June	4.441	.....	16.422	17.038	.....	.....
July	4.350	.....	16.171	16.777	.....	.....
August	4.360	.....	15.953	16.469	.....	.....
September	4.270	.....	15.773	16.080	.....	.....
October	4.059	.....	14.446	14.935	.....	.....
November	4.266	.....	14.706	15.238	.....	.....
December	4.099	.....	13.762	14.214	.....	.....
Year	4.556	.....	16.570	17.107	.....	.....

St. Louis quotations, cents per pound. London pounds sterling per long ton.

Antimony, Quicksilver, and Platinum

	Antimony (a) New York		Quicksilver (b) New York		Platinum (c) New York	
	1930	1931	1930	1931	1930	1931
January	8.606	7.317	121.192	103.000	61.923	36.000
February	8.830	7.069	120.500	100.205	59.909	34.000
March	8.236	7.127	118.808	100.423	54.769	29.538
April	7.740	6.888	114.000	102.077	46.462	26.346
May	7.454	6.524	117.269	101.140	46.000	24.980
June	7.057	.....	118.600	.....	46.000	.....
July	6.976	.....	117.462	.....	43.692	.....
August	7.839	.....	116.000	.....	41.462	.....
September	7.773	.....	113.620	.....	36.080	.....
October	7.288	.....	110 596	.....	36 000	.....
November	7.105	.....	106.717	.....	36.000	.....
December	7.099	.....	105.346	.....	36.000	.....
Year	7.667	.....	115.009	.....	45.358	.....

(a) Antimony quotations in cents per pound, for ordinary brands. (b) Quicksilver in dollars per flask of 76 lb. (c) Platinum in dollars per ounce.

Pig Iron[1] and Aluminum

	Bessemer		Basic		No. 2 Foundry		Aluminum	
	1930	1931	1930	1931	1930	1931	1930	1931
Jan	19.00	17.50	18.50	17.00	18.50	17.00	24.300	23.300
Feb	19.00	17.29	18.50	16.79	18.50	16.79	24.300	23.300
March	19.00	17.00	18.50	16.50	18.50	16.50	24.300	23.300
April	19 00	17.00	18.50	16.50	18.50	16.50	24.300	23.300
May	19.00	17.00	18.50	16.38	18.50	16.44	24.300	23.300
June	19 00	.....	18.50	.....	18.50	.....	24.140	.....
July	18.62	.....	18.12	.....	18.12	.....	23.300	.....
Aug	18.50	.....	18 00	.....	18.00	.....	23.300	.....
Sept	18.38	.....	17 76	.....	17 88	.....	23.300	.....
Oct	17.85	.....	17.00	.....	17.22	.....	23.300	.....
Nov	17.50	.....	17.00	.....	17.00	.....	23.300	.....
Dec	17 50	.....	17 00	.....	17.00	.....	23.300	.....
Year	18.53	.....	17.99	.....	18.02	.....	23.787	.....

Iron in dollars per long ton. Aluminum in cents per pound, 99 per cent grade.

[1]F.o.b. Mahoning and Shenango valley furnaces; freight to Pittsburgh, $1.76.

Monthly Crude Copper Output in Short Tons

	1929 Total	1930 Total	1931 Jan.	1931 Feb.	1931 Mar.	1931 Apr.
Domestic						
Alaska shipments	21,947	18,953	837	627	563	885
Calumet & Arizona	65,246	45,161	3,236	3,237	3,189	.....
Magma	19,118	15,940	1,197	1,202	1,223	1,213
Miami	29,567	34,568	2,348	1,745	2,025	1,995
Nevada Cons	133,140	70,990	.....	.....	(d) 16,393	.....
Old Dominion (a)	11,172	10,428	577	576	580	587
Phelps Dodge (b)	111,026	72,308	5,155	5,184	5,188	5,180
United Verde Extens	29,669	21,908	1,412	1,610	1,618	1,537
Tennessee Corp	7.870	7,772	659	585	611	609
Foreign						
Andes Copper	60,538	47,428	3,503	3,498	.....	.....
Braden	88,155	79,923	8,595	8,595	.....	.....
Boleo, Mexico	12,898	13,940	.....	.....	(d) 3,250	.....
Chile	150,247	89,100	7,120	7,117	.....	.....
Furukawa, Japan	17,767	18,536	1,489	1,542	1,563	.....
Howe Sound	21,516	22,633	.....	.....	.....	.....
Messina	(c) 7,200	.....	857	749	843	764
Mt. Lyell	9,731	10,878	.....	.....	(d) 2,699	.....
Sumitomo, Japan	20,180	15,429	1,324	1,129	1,400	.....

(a) Includes Arizona Commercial. (b) Moctezuma is included. (c) Estimated. (d) Three months.

Monthly Production of Primary Copper from U. S. Mines and Daily Rate (Short Tons)

	1929 Monthly Production	1929 Daily Rate	1930 Monthly Production	1930 Daily Rate	1931 Monthly Production	1931 Daily Rate
January	86,324	2,785	67,838	2,188	48,059	1,550
February	84,735	3,026	59,196	2,114	47,504	1,697
March	93,698	3,023	61,216	1,975	48,702	1,571
April	94,902	3,163	60,450	2,015	46,883	1,563
May	93,392	3,013	60,238	1,943	.....	.....
June	82,354	2,745	56,743	1,891	.....	.....
July	79,229	2,556	54,249	1,750	.....	.....
August	78,885	2,545	56,779	1,832	.....	.....
September	79,402	2,647	56,584	1,886	.....	.....
October	82,575	2,664	55,954	1,805	.....	.....
November	75,934	2,531	53,141	1,771	.....	.....
December	74,772	2,412	48,518	1,565	.....	.....
Total	1,006,203	.....	690,263	.....	191,148	.....
Monthly average	83,850	.....	57,522	.....	47,787	.....
Av. of daily rate	.....	2,757	.....	1,891	.....	1,593

Mining Share Prices—Month of May, 1931

Company Name	High	Low	Last	§Most Recent Dividend
NEW YORK STOCK EXCHANGE				
Ahumada Lead	0.37½	0.25	0.25	April, 1927 0.12½
Alaska Juneau	17⅞	12½	16½	Ap. 10, My. 1, 1931 Q 0.10
American Metal	14¼	9.00	10½	December, 1930 Q 0.25
Am. Metal, pfd	78	53½	53½	My. 21, Je. 1, 1931 Q 1.50
Am. Sm. & Ref	38	27½	27½	Ap. 17, My. 31, 1931 Q 1.00
Am. Sm. & Ref. 2nd, pfd.	95	87½	87½	My. 8, Je. 1, 1931 Q 1.50
Am. Sm. & Ref., pfd	129	117½	119	My. 8, Je. 1, 1931 Q 1.75
Am. Zinc., L. & S	5.00	3.62½	4.00	May, 1917 1.00
Am. Zinc, L. & S., pfd.	38½	28½	30	October, 1930 Q 1.50½
Anaconda	28½	22½	22½	Ap. 11, My. 18, 1931 Q 0.37½
Andes Copper	11½	10½	10½	Ja. 10, Fe. 9, 1931 Q 0.25
Butte C. & Z	0.87½	0.75	0.75	December, 1929 0.50
Butte & Superior	1.50	1.25	1.25	December, 1929 Q 0.50
Callahan Zinc-Lead	0.62½	0.62½	0.62½	December, 1920 0.50
Cal. & Arizona	33	26½	27	June, 1930 0.50
Cal. & Hecla	7.62½	5.87½	5.87½	June, 1930 0.50
Cerro de Pasco	18	15½	15½	Ap. 16, My. 1, 1931 Q 0.50
Dome Mines	13½	9.75	11½	Mh. 31, Ap. 20, 1931 Q 0.25
Federal M. & S	49	35	35	June, 1927 10.00
Federal M. & S., pfd	....	....	94*	My. 25, Je. 5, 1931 Q 1.75
Freeport Texas	30	24½	25½	My. 15, Je. 1, 1931 Q 0.75
Granby Con	15	11	11	Ja. 16, Fe. 2, 1931 Q 0.50
Greene Cananea	73½	73½	73½	July, 1930 0.75
Homestake	98	91	91	My. 20, My. 25, 1931 M 0.50
Howe Sound	19⅜	16	16	Mh. 31, Ap. 15, 1931 Q 0.75
Inspiration	7.50	5.25	6.00	July, 1930 0.50
International Nickel	15½	10	10½	Je. 1, Je. 30, 1931 Q 0.15
Int. Nickel, pfd	118½	114	114	Ja. 3, Fe. 2, 1931 Q 1.75
Kennecott	22½	16½	16½	Mh. 12, Ap. 1, 1931 Q 0.50
McIntyre-Porcupine	24⅜	19½	21	My. 1, Je. 1, 1931 Q 0.25
Magma Copper	18	13½	14	Mh. 31, Ap. 15, 1931 Q 0.50
Miami Copper	7.50	4.75	5.00	August, 1930 0.375
Mother Lode	0.62½	0.50	0.50	June, 1930 0.10
National Lead	113	88½	90	Je. 12, Je. 30, 1931 Q 1.25
National Lead, pfd. A	141½	140	140	My. 29, Je. 15, 1931 Q 1.75
National Lead, pfd. B	118	118	118	Jy. 17, Au. 1, 1931 Q 1.50
Nevada Con	10½	7.12½	7.12½	Mh. 13, Mh. 31, 1931 Q 0.25
Noranda Mines	29½	15½	17	October, 1930 0.50
Park Utah Con	1.50	1.12½	1.12½	July, 1929 Q 0.20
Patiño M. & E	9.00	8.50	8.50	December, 1929 4s.
Phelps Dodge	18⅛	12½	13	De. 13, Ja. 2, 1931 Q 0.50
Rand Mines	....	....	34½*	August, 1930 1.52
St. Joseph Lead	17½	15	15½	Je. 9, Je. 20, 1931 Q 0.25
Seneca Copper	1.12½	0.50	0.62½	....
Tennessee Corp	6.87½	5.50	5.50	Fe. 28, Mh. 16, 1931 Q 0.125
Texas Gulf Sulphur	43½	34½	35½	Je. 1, Je. 15, 1931 Q 0.75
U. S. S. R. & M	18⅜	15	15	Ap. 2, Ap. 15, 1931 Q 0.25
U. S. S. R. & M., pfd	45	40	41½	Ap. 2, Ap. 15, 1931 Q 0.875
Utah Copper	100½	98½	100	Mh. 13, Mh. 31, 1931 Q 2.00
Vanadium Corp	46½	25½	26⅛	Fe. 2, Fe. 16, 1931 Q 0.75
NEW YORK CURB EXCHANGE				
Aluminum Co. of Am	156	93½	93½	....
Alum. Co. of Am., pfd.	108½	100	100½	Mr. 14, Ap. 1, 1931 Q 1.50
Anglo-Chilean Con	9.50	6.12½	6.12½	....
Bunker H. & S	45¼	30	30	(c)
Carnegie Metals	1.00	1.00	1.00	....
Con. Coppermines	2.62½	2.00	2.12½	....
Copper Range	5.75	5.00	5.00	July, 1930 0.25
Cresson Con	0.43¾	0.37½	0.43¾	Mh. 31, Ap. 10, 1931 Q 0.01
Cusi Mexicana	0.50	0.37½	0.43¾	....
Evans-Wallower	1.25	0.50	0.62½	....
Federated Metals	8.25	8.00	8.00	Ja. 5, Ja. 15, 1931 Q 0.25
Hecla Mining	5.50	4.37½	4.37½	My. 15, Je. 15, 1931 Q 0.10
Hollinger Con	8.00	6.50	7.00	Je. 3, Je. 17, 1931 M 0.05
Hudson Bay M. & S	4.75	3.50	3.50	....
Iron Cap Copper	0.75	0.75	0.75	....
Mayflower Associates	35	32	32	Je. 1, Je. 15, 1931 Q 0.50
Mining Corporation	2.37½	2.00	2.00	December, 1929 0.12½
New Jersey Zinc	38½	35	35½	Ap. 20, My. 9, 1931 Q 0.50
Newmont Mining	37½	25½	25½	Mh. 31, Ap. 15, 1931 Q 1.00
N. Y. and Honduras	11½	10½	11	Ap. 14, Ap. 25, 1931 QX 0.50
Nipissing	1.25	0.93¾	0.93¾	Mh. 31, Ap. 20, 1931 Q 0.075
Ohio Copper	0.37½	0.25	0.37½	September, 1926 0.03
Premier Gold	0.87½	0.68¾	0.68¾	Mh. 13, Ap. 4, 1931 Q 0.03
Quincy	....	....	5.00 *	March, 1920 1.00
Shattuck Denn	3.87½	3.25	3.25	....
So. Am. Gold & Plat	2.50	1.00	1.37½	....
Teck-Hughes	8.12½	6.37½	7.12½	Ap. 17, My. 1, 1931 Q 0.15
Tonopah Mining	....	....	0.50 *	Octobor, 1929 0.07½
United Eastern	....	....	0.06¼*	....
United Verde Ex	9.50	5.87½	5.87½	Ap. 2, My. 1, 1931 Q 0.50
Utah-Apex	1.00	0.75	0.75	December, 1929 0.025
Yukon Gold	0.43¾	0.43¾	0.43¾	June, 1918 0.02
BOSTON STOCK EXCHANGE				
Ariz. Commercial	0.90	0.85	0.85	Fe. 21, Fe. 28, 1931 IL 1.00
East Butte	0.27	0.25	0.27	Fe. 16, Mh. 4, 1931 L 2.00
Isle Royale	3.75	3.00	3.25	March, 1930 0.50
Mohawk Mining	18½	15½	16	Ap. 30, My. 30, 1931 Q 0.25
Old Dominion	3.00	2.62½	2.62½	December, 1918 1.00
Utah Met. & Tunnel	0.31	0.29	0.30	December, 1927 0.30
¶ MONTREAL				
Asbestos Corp	0.45	0.25	0.40	January, 1926 1.50
Asbestos Corp., pfd	1.25	1.00	1.00	January, 1930 1.75
Consolidated M. & S	113	77	77	De. 30, Ja. 15, 1931 SAX 6.25

Company Name	High	Low	Last	§Most Recent Dividend
SPOKANE				
Constitution	0.06½	0.04	0.04	....
Dayrock	0.70	0.55	0.70	March, 1930 0.03
Golconda	0.20	0.15	0.16½	July, 1929 0.02
Jack Waite Con	0.31	0.19	0.31	....
Los Lugos	....	....	(c)	....
Mexican Premier	0.10	0.10	0.10	January, 1930 0.01
Montana Mines	0.15	0.13	0.14¾	....
Noble Five	0.03	0.03	0.03	January, 1930 0.005
Pend Orielle	0.70	0.65	0.65	....
Sherman Lead	0.28	0.25	0.25	March, 1930 0.01
Sidney	....	....	(c)	October, 1929 0.01
Sunshine Mining	1.18	1.08	1.08	December 20, 1930 Q 0.03
Tamarack & Custer	0.19¾	0.18½	0.19½	September, 1924 0.25
SALT LAKE CITY				
Chief Con	0.51	0.45	0.49	February, 1928 0.10
Combined Metals	....	....	0.08½*	....
Eureka Bullion	0.21½	0.11½	0.17½	....
Eureka Lilly	0.12½	0.10	0.12	....
Moscow Silver	0.35	0.25	0.25	....
New Quincy	0.04¾	0.04½	0.04¾	September, 1929 Q 0.10
North Lily	0.90	0.80	0.87	January, 1930 0.15
Park Bingham	0.75	0.50	0.50	....
Park City Con	0.17½	0.10	0.10	....
Rico Argentine	0.04½	0.03¾	0.03¾	December, 1929 0.03
Silver King Coalition	3.97½	3.50	3.50	De. 20, Ja. 2, 1931 Q 0.15
Tintic Lead	1.20	1.10	1.10	....
Tintic Standard	3.42½	3.15	3.15	March 31, 1931 Q 0.10
Walker Mining	1.40	1.15	1.15	April, 1930 0.075
¶ TORONTO				
Abana Mines	0.17	0.08¾	0.09	....
Amulet Mines	0.31	0.24½	0.25	....
Base Metals	0.15½	0.11	0.11	....
Barry-Hollinger	1.05	0.90	1.00	....
Canam Metals	0.04	0.03	0.03	....
Castle-Trethewey	0.15½	0.15	0.15½	....
Central Manitoba	0.14	0.06	0.06	....
Falconbridge	1.35	1.25	1.25	....
Howey Mines	0.31	0.24	0.29	....
Keeley	0.26	0.26	0.26	March, 1928 0.04
Kirkland Lake	0.82	0.67	0.69	....
Lake Shore	28	26½	27½	Je. 1, Je. 15, 1931 QB 0.60
Sherritt Gordon	0.90	0.59	0.60	....
Siscoe Gold	0.53½	0.40	0.42	....
Sylvanite	0.92½	0.71	0.71	De. 5, De. 20, 1930 SA 0.02
Treadwell-Yukon	2.00	1.75	1.75	....
Ventures	0.53	0.41	0.42½	....
Vipond Con	1.08	0.85	0.85	April, 1927 0.03
Waite-A.-M	1.31	1.05	1.05	....
Wright-Hargreaves	3.18	2.65	2.74	Mh. 14, Ap. 1, 1931 0.025
ST. LOUIS, CINCINNATI, AND DENVER				
Consolidated L. & Z	2.25	2.00	2.00	December, 1929 0.125
Eagle-Picher	5.50	4.50	4.50	April, 1930 0.20
Eagle-Picher, pfd	89	89	89	De. 31, Ja. 15, 1931 Q 1.50
Empire Chief	0.02	0.01½	0.01½	....
Star of Utah	0.61	0.36	0.46½	....
Tungsten Prod	0.10	0.08	0.10	....
West Gold	0.01	0.00¾	0.00¾	....
SAN FRANCISCO, LOS ANGELES, AND COLORADO SPRINGS				
California Copper	0.50	0.25	0.50	....
(a) Golden Cycle	14	13¾	14	My. 31, Je. 10, 1931 Q 0.40
(a) Granite Gold	0.19	0.18	0.18	Mh. 27, Ap. 1, 1931 Q 0.01
Idaho-Maryland	0.48½	0.39	0.44	....
Tom Reed	1.15½	0.95	0.97	Mh. 16, Ap. 1, 1931 0.03
(a) United Gold	0.08½	0.07½	0.07½	February, 1930 0.01

‡ LONDON

Company Name	High	Low	Last	Most Recent Dividend (Per Cent, Unless Noted)
Anglo American	16/1½	9/4½	10/7½	22½, Feb. 19. 1930
Aramayo Mines	22/6	20/–	20/–	5, Oct. 23, 1929
Burma Corporation	8/6	5/4½	5/4½	1¼, Dec. 10. 1930(b)
Camp Bird	5d	3d	4½d	16¼, April 25, 1928
Fresnillo	....	....	7/6*	25 cents, Feb. 12, 1930
Frontino & Bolivia	10/7½	10/3	10/7½	3¾, January, 1929
Lake View & Star	10/7½	8/–	8/1½	11¼, 1921
Mexican Corporation	4/9	3/–	3/–	10, Oct. 24, 1929
Oroville Dredging	1/9	1/–	1/3	37½, May 16, 1930
Rhokana Corporation	126/3	60/–	77/6	....
Rhodes.-Select. Trust	16/3	10/3	11/3	....
Rio Tinto	476/3	297/6	315/–	10s, May 1, 1931
St. John del Rey	21/3	18/6	18/9	8¾, May 1, 1931
San Francisco Mines	12/6	7/6	8/–	10, Jan. 7, 1931
Santa Gertrudis	7/3	6/3	6/6	7½, Jan. 8, 1931
Selukwe	3/–	1/3	1/9	6¼, April 2, 1917
So. American Copper	2/1½	1/3	1/3	....
Tanganyika	25/3	19/4½	21/3	2½, Aug. 2, 1930
Wiluna Gold	18/3	14/3	14/3	....
Union Minière	4,690	4,445	4,445†	240 francs, July, 1931

Salt Lake Stock Exchange courtesy J. A. Hogle & Company, Spokane Standard Exchange courtesy the Pohlman Investment Company. *Not traded in †Belgian Francs. ‡The above London quotations are for the month ended May 19. ¶Toronto and Montreal prices are for the month ended May 25. Q, quarterly; I, initial; M, monthly; X, extra; SA, semi-annual; L, liquidating; B, plus bonus. §Total dividends paid during the month will be found tabulated in the Market and Financial News Section. Dates here given are those of closing of books and payment of dividend. (a) Bid prices. (b) 1¼% (2 annas) dividend, and bonus of ¼% (1 anna). (c) This quotation not available.